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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

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New England Water Works Association.
ORGANIZED 1882.

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PROGRESS OF WATER DISINFECTION IN MARYLAND.

BY ROBERT B. MORSE, CHIEF ENGINEER, AND HARRY R. HALL, ASSISTANT CHIEF ENGINEER, MARYLAND STATE DEPARTMENT OF HEALTH.

[*Read February 9, 1916.*]

There are eighty-three public water supplies in Maryland, serving about 842 500 people, — 62.1 per cent. of the estimated total population of 1 357 374. Several community systems delivering water to small groups of houses, and also institutional supplies, are not included in this number.

The state, through its Board of Health, has had, since 1914, strict supervisory control over the design, construction, and operation of water systems. No material extensions of, nor alterations in, existing systems can be legally made, nor can new supplies be installed, unless complete plans and specifications covering the proposed work are submitted to the State Board of Health for approval and a written permit is granted by that body. Moreover, when deemed necessary for the public health or welfare, the Board may require existing water systems extended or altered, and it is empowered to compel the installation of public supplies in communities not served. It is the duty of the corporate officers to raise the funds necessary for carrying out the work required, and they may do this, if they wish, by issuing bonds without special legislative enactment and without a referendum vote.

Broad as is the control of the state over the design and construction of water supplies, it is no more liberal than is its authority

over the operation of existing systems, in so far as the public health is affected. If the State Board of Health finds that any water plant is not properly operated, it may require a change of method, and may, when necessary, force the employment of competent attendants, it even being enabled to attain this end by appointing attendants of its own selection, at the cost of the municipality or water company owning the plant. Possible arbitrary action, however, is precluded by a provision in the law allowing appeal to the local county court, before which the Board would have to prove the reasonableness of its act.

Prior to the passage of the law giving the State Board of Health such complete power over water supplies, there was no legislation which specifically enabled it to compel necessary improvements. The laws existing before 1914 merely conferred the right to investigate and report upon water systems. There was one provision which made it a misdemeanor to pollute sources of water supply, and imposed penalties for offenses of this character, but there was nothing which actually gave the Board the power to force a municipality or water company to provide a safe water supply.

The engineering division of the State Board of Health was organized in June, 1912, under a law passed in 1910, which also provided for the formation of several other divisions. This act prescribed general duties of investigation, as mentioned above. The early engineering studies indicated plainly the need of complete supervisory power over the water supplies of the state, and this need was satisfied by the passage of the water supply and sewerage act of 1914.

An effort has been made by the State Board of Health to use its power in a judicious manner and not to attempt coercive measures where proper improvements could be brought about in other ways. It has not yet been necessary to invoke the full extent of its legal power, and in no case has the Board been compelled to appoint operating attendants for water supplies which have been improperly cared for, although in some instances this might well have been done.

In 1912, when the engineering investigations were begun, it was found that, in general, knowledge of the condition of the public

water supplies in the state was meager. Analyses of the water from many of the supplies had been made occasionally, but no systematic method of examination had been followed. The Baltimore system was looked after by the city water and health departments, and consequently received little or no attention from the State Board of Health.

The state's investigations commenced to show that many of the water systems were badly in need of attention. The surface supplies were derived from streams fed by watersheds containing habitations, in many cases providing numerous sources of contamination, and, in general, protection was not offered by long storage, filtration, or other treatment. Water was usually taken from the stream at an intake dam, and passed into a distributing reservoir of insufficient capacity to provide a safe period of storage. Moreover, water from some of the tubular well systems was found to be polluted, because the wells either were of too shallow depth and located in the midst of thickly settled districts where sources of pollution were numerous, or were driven in rock containing fissures. Some supplies previously considered to be beyond suspicion were found, upon close investigation, to be in a bad condition and a menace to the public health.

In a large number of the instances where supplies were polluted, the water was satisfactory from a physical standpoint, there being an absence of color, turbidity, and other objectionable characteristics. This was naturally true in the case of most well and spring waters. The water from streams fed by mountain watersheds, and from watersheds containing much wooded or uncultivated land, was also generally in good physical condition.

Where water, otherwise acceptable, was found to be in an unsafe sanitary condition, filtration did not appear to be necessary or even advisable for assuring the proper degree of purity. Expense and the improbability of proper operation are two factors which would make filtration plants undesirable for many of the small systems which abound in Maryland. Consequently, disinfection was resorted to wherever it would serve the purpose. There were, however, a considerable number of surface supplies derived from streams flowing through cultivated country and furnishing a water occasionally or persistently turbid. Such supplies as these natu-

rally require filtration. Disinfection in connection with filtration is general, and is required in all new installations. While the writers' assistants have been able to obtain good results from several filter plants without the addition of disinfectants, the character of attention which small works ordinarily receive makes their use essential.

Prior to the establishment of the engineering division of the State Board of Health, in 1912, there were only four disinfecting plants in operation on water supplies in Maryland. Two of these were located on the Gunpowder and Jones Falls systems, of Baltimore; and two, owned by the Baltimore County Water and Electric Company, were at the Avalon and Herring Run plants which serve large sections in Baltimore County near the city. At Avalon, disinfection was carried on in conjunction with filtration. All these installations used hypochlorite of calcium, and at Herring Run ozone was employed at times.

Since 1912, many towns in other parts of Maryland have been provided with purification plants, and it is a striking fact that, of the 842 565 persons served by public water supplies at the present time, 745 149, or 88.4 per cent. (approximately 54.9 per cent. of the population of the state), use water which is treated by either filtration or disinfection, or both.

The number of public systems in the state using raw, filtered, or disinfected ground and surface water, and the total populations of the communities served, are shown by Table 1.

There are eighty-three public water supplies in Maryland, sixty-one of which derive their water from underground sources. The population thus served amounts to 102 099. The number of consumers is small in comparison with the number of systems, because these supplies, in general, are located in the smaller towns. The remaining twenty-two systems take water from surface streams and serve a population of 740 466. The large population using surface water is accounted for by the fact that Baltimore and most of the other places of considerable size are thus supplied. Ground waters are used by 12.1 per cent. of the people served by public systems, and by 7.5 per cent. of the total population of the state. The corresponding figures for surface waters are 87.9 and 54.6 per cent.

TABLE 1. — CLASSIFICATION OF PUBLIC WATER SUPPLIES IN MARYLAND.

UNTREATED.				TREATED.				
Number of Supplies	Population of Communities Served.	Per Cent. of Total Population of State.	Per Cent. of Population Using Public Supplies.	Form of Treatment.	Number of Supplies.	Population of Communities Served.	Per Cent. of Total Population of State.	Per Cent. of Population Using Public Supplies.
				Ground-Water Supplies.				
55	85 815	6.3	10.2	Disinfected only	5	10 284	0.8	1.2
				Filtered only	1	6 000	0.4	0.7
				Total treated	6	16 284	1.2	1.9
				Surface-Water Supplies.				
7	11 601	0.9	1.4	Disinfected only	9	76 916	5.7	9.1
				Filtered and disinfected	4	645 760	47.6	76.7
				Total disinfected	13	722 676	53.3	85.8
				Total filtered only	2	6 189	0.4	0.7
				Total treated	15	728 865	53.7	86.5
				All Supplies.				
62	97 416	7.2	11.6	Disinfected only	14	87 200	6.5	10.3
				Filtered and disinfected	4	645 760	47.6	76.7
				Total disinfected	18	732 960	54.1	87.0
				Total filtered only	3	12 189	0.8	1.4
				Total treated	21	745 149	54.9	88.4

Total population served by public water supplies 842 565
Total population of state 1 357 374

Of the ground-water supplies, six are treated, while of the surface supplies only seven deliver untreated water, and these to only 11 601 people. The six plants for purifying ground water serve 16 284 persons, and communities with a total population of 728 865, supplied by fifteen systems, are using treated surface water. There are eighteen public supplies with disinfecting plants, and three in which the water is filtered but not disinfected. A population of 732 960 is served with disinfected water, 12 189 with water filtered only, and 97 416 use raw water. Thus, 54.1 per cent. of the total population of Maryland drink disinfected, 54.9 per cent. treated, and only 7.2 per cent. raw, water. Of the total number of people served by public water systems, 87.0 per cent. use disinfected, 88.4 per cent. treated, and 11.6 per cent. raw, water.

Not only is the influence of water purification felt by the public water supplies, but it has reached to state and private institutions as well. There are, as shown by Table 2, six institutions, embracing a population of 2 352, where the water receives treatment of some kind, and in all but one of these it is disinfected. Included in this number are a penal institution, a tuberculosis sanatorium and four educational institutions.

TABLE 2.

CLASSIFICATION OF TREATED INSTITUTIONAL WATER SUPPLIES IN MARYLAND.

Class.	Form of Treatment.	No. of Supplies.	Population Served.
Ground water	Disinfected only	2	652
Surface water	Disinfected only	2	1 100
	Filtered and disinfected	1	350
	Filtered only	1	250
All supplies treated		6	2 352
Disinfected supplies		5	2 102

The location and nature of the public water systems and treated institutional supplies are shown in Fig. 1. The universal use of ground-water sources, and the consequent scarcity of purification works, in the section of the state east of Chesapeake Bay, is notable.

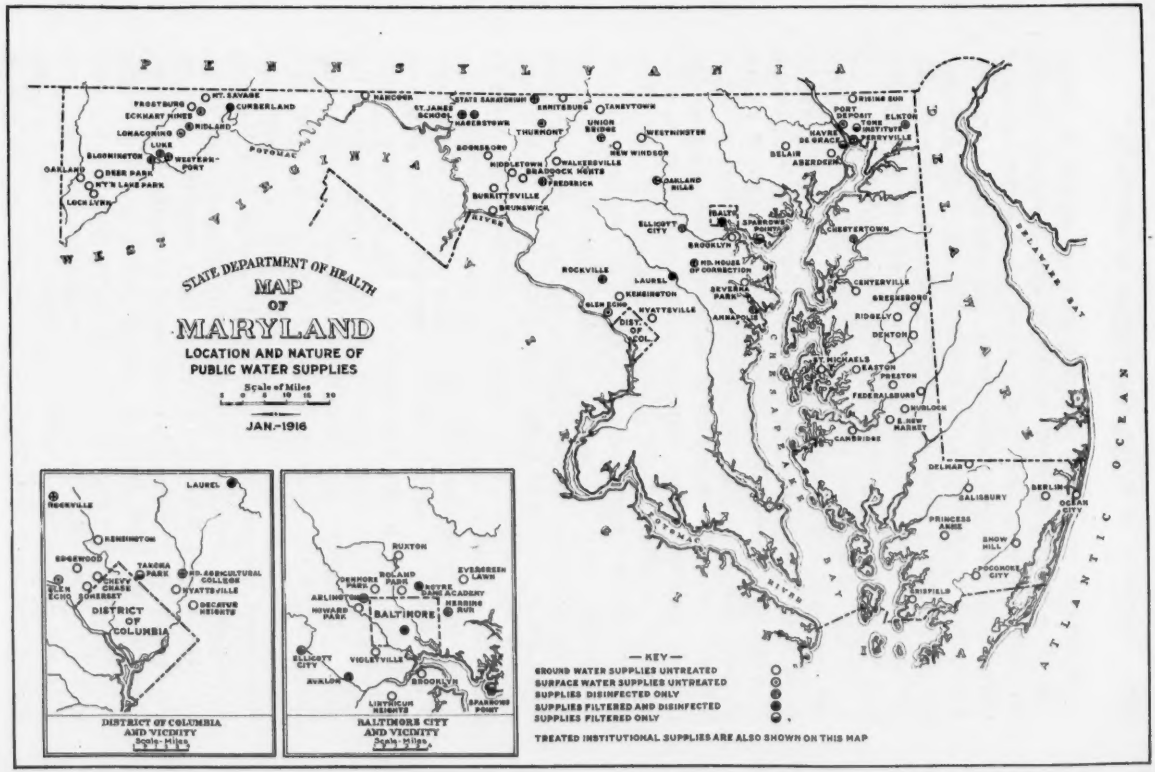

STATE DEPARTMENT OF HEALTH
MAP
OF
MARYLAND
LOCATION AND NATURE OF
PUBLIC WATER SUPPLIES
Scale of Miles
JAN.-1916
PENNSYLVANIA
WEST VIRGINIA
VIRGINIA
DELAWARE
ATLANTIC OCEAN
DELAWARE BAY
CHESAPEAKE BAY
POTOMAC RIVER
— KEY —
GROUND WATER SUPPLIES UNTREATED
SURFACE WATER SUPPLIES UNTREATED
SUPPLIES DISINFECTED ONLY
SUPPLIES FILTERED AND DISINFECTED
SUPPLIES FILTERED ONLY
TREATED INSTITUTIONAL SUPPLIES ARE ALSO SHOWN ON THIS MAP
DISTRICT OF COLUMBIA AND VICINITY
Scale-Miles
BALTIMORE CITY AND VICINITY
Scale-Miles

FIG. 1.

Disinfection by means of hypochlorite of calcium or liquid chlorine is naturally the most common method practiced, although one small mill town uses distilled water, which is the condensed exhaust from the steam turbines in the mill, and there is an ozone plant which is operated in conjunction with one of the hypochlorite installations. There is a possibility that ultra-violet ray disinfection will shortly be introduced, as its use is under consideration for a mechanical filter plant now being constructed.

The type of apparatus suitable for hypochlorite or liquid chlorine treatment in any particular case depends upon the method by which water is supplied. Where the flow of water to be treated is at most times substantially uniform, as in the case of certain pumping plants, or in gravity lines discharging into reservoirs, a manually controlled apparatus is sufficient. Where fluctuations occur in the rate of flow, automatic control devices are essential for proper results. Liquid chlorine plants, so-called, introduce chlorine into the water either as a gas or in solution. The gas feed, usually called " direct feed," is well adapted for use where no water under pressure, for dissolving the gas, can be easily obtained. There are no direct-feed plants in Maryland at the present time, and only one, at Perryville, is regulated automatically, although automatic equipment is about to be furnished at Frederick.

The early disinfecting plants, as stated previously, all made use of hypochlorite of calcium, and with effective results. Those on the Avalon and Herring Run supplies of the Baltimore County Water and Electric Company were the first to be installed in the state. The former was constructed in 1908, and the latter during the year following. Late in 1910 the Jones Falls supply for Baltimore was first disinfected, and in June, 1911, the Gunpowder River plant was put into use. Until 1913 these were the only installations of disinfecting apparatus used for water purification in Maryland. A filtration plant had been previously built by the Washington County Water Company, to supply Hagerstown from Antietam Creek during dry periods, and hypochlorite dosing apparatus had been provided; but the disinfectant was not used until the summer of 1913. About the same time, the State Board of Health constructed a plant for the Ellicott City system. Cumberland next followed, during the fall of the same year, by putting

into operation a hypochlorite plant in conjunction with the mechanical filters on its new supply. In December, the mountain supply of Hagerstown was furnished with hypochlorite apparatus. A typhoid fever epidemic at Rockville during February, 1914, made necessary the construction of an emergency hypochlorite plant by the State Board of Health, for treating the supply derived from tubular wells driven in rock and proven to be the cause of the disease. The first liquid chlorine apparatus was put into operation at Union Bridge in January, 1914, for treating about 120 000 gal. of water derived from tubular wells driven in limestone rock. An ozone plant had been installed in 1909 at the Herring Run supply of the Baltimore County Water and Electric Company, but at first it was used, so the writers are informed, only experimentally.

After the powers of the State Board of Health were broadened, in 1914, and an increased appropriation was provided for sanitary engineering work, water purification plants were naturally introduced at a more rapid rate than previously. At the present time there are eleven liquid chlorine installations treating about 5 600 000 gal. of water daily, and eleven hypochlorite plants treating approximately 90 600 000 gal. daily. Of the latter amount, eighty million gallons are delivered to Baltimore City.

Data concerning the disinfecting plants in Maryland are shown in Table 3.

Changes are taking place continually in the water supply situation in this state, and it is expected that the number of disinfecting plants soon will be increased and that alterations will be made in some of the water supplies, which will involve plants now in operation. At Annapolis the existing liquid chlorine plant probably soon will be used in conjunction with a mechanical filtration plant, the construction of which is contemplated, and at the Maryland House of Correction the liquid chlorine apparatus already installed will supplement purification by slow sand filters which were recently designed by the writers, and which will soon be built. A filtration plant is being constructed at Westminster, and one is being designed for the Springfield State Hospital. Liquid chlorine probably will be used for both of these installations. Liquid chlorine will soon replace hypochlorite at Westernport, and the

TABLE 3.

DATA CONCERNING WATER SUPPLY DISINFECTING PLANTS IN MARYLAND.

Place.	Population (Estimated 1916).	Type of Plant.	Character of Supply.	Date.	Average Amount Treated Daily (Gallons).	Chlorine. Parts per Million.	Where Chemical is Applied.	Character of Attention.
Plants for Disinfection Only.								
Annapolis	8 656	Liquid chlorine	Surface	1915	1 224 000	0.32	Pump suction	Good.
Arlington	5 250	Liquid chlorine	Ground	1914	72 000*	0.30	Pump suction	Indifferent.
Bloomington	372	Liquid chlorine	Surface	1915	15 000	...	Supply main	Not yet in continuous operation.
Chestertown	2 730	Hypochlorite	Ground	1915	170 000	0.23	Pump suction	Good.
Ellicott City	1 148	Hypochlorite	Surface	1913	70 000	...	Pump suction	Neglected — used only occasionally.
Frederick	11 056	Liquid chlorine	Surface	1915	1 000 000	0.36	Supply main under pressure	Indifferent.
Hagerstown	25 500	Hypochlorite†	Surface	1913	2 500 000	0.44	Before entering	Good.
		Liquid chlorine		1914		0.40	supply main	
Herring Run (Baltimore County)	25 493	Hypochlorite	Surface	1909	2 800 000	0.40	Pump well	Good.
		Ozone		1909				
Luke	950	Distillation	Surface	1912	150 000	Water is condensed exhaust from steam turbines in mill of W. Va. Pulp and Paper Co.		
Maryland Agricultural College	300	Hypochlorite	Surface	1916	30 000	...	Pump suction	Not yet in full operation.
Maryland House of Correction	800	Liquid chlorine	Surface	1915	200 000	0.60	Pump suction	Intermittent — much better than at first.
Maryland Tuberculosis Sanatorium	600	Hypochlorite†	Ground	1915	90 000	0.89	Pump suction	Good.
		Liquid chlorine		1915		0.67		

Oakland Mills	200	Hypochlorite	Ground	1915	9 000	0.83	Storage tank	Neglected — used only occasionally.
Perryville	632	Liquid chlorine	Surface	1915	300 000	0.50	Supply main	Indifferent.
Rockville	1 221	Liquid chlorine	Ground	1916	30 000	0.22	Collect. res.	Good.
St. James School	52	Hypochlorite	Ground	1915	4 000	1.50	Storage tank	Good.
Union Bridge	883	Liquid chlorine	Ground	1914	120 000	0.35	Pump suction	Good.
Westernport	3 109	Hypochlorite	Surface	1914	450 000	0.40	Intake at dam	Neglected at first, at present good.
Plants for Filtration and Disinfection.								
Avalon (Baltimore County)	30 197	Hypochlorite	Surface	1908	1 500 000	0.80	Outlet of coagulating basin	Good.
Baltimore City	587 112	Hypochlorite	Surface	1915	80 000 000	0.30‡	Filtered water	Good.
Cumberland	25 843	Hypochlorite	Surface	1913	5 500 000	0.20	Inlet to coagulating basin	Good.
Laurel	2 608	Hypochlorite	Surface	1915	70 000	....	Filtered water	Not yet in continuous operation.
Notre Dame	350	Liquid chlorine	Ground	1915	30 000	0.25	Pump suction	Good.

* This amount is mixed with raw water from other sources.

† Now kept for emergency use.

‡ As high as 3.0 parts per million of available chlorine have been used in treating the raw water before the filtration plant was installed.

same change is being considered for the Baltimore filtration plant, for which hypochlorite was recently quoted at $290 a ton, on the basis of a yearly contract. There is a marked tendency to use liquid chlorine instead of hypochlorite of calcium in connection with old as well as new installations, and the high price which now has to be paid for the latter will stimulate this movement.

The amount of chemical used at the disinfecting plants in Maryland has varied widely according to local conditions. It has ranged from 0.2 to 3.0 parts per million of available chlorine in the case of hypochlorite treatment, and from 0.25 to 0.67 parts where liquid chlorine is used. Where the disinfectant is applied to a spring or well water, or to the effluent from a well-operated filtration plant, the amount required is usually near the minimum mentioned above. In the case of turbid waters, larger amounts have been found necessary for proper treatment, and at times of extreme turbidity excessive quantities are required. In the treatment of the Baltimore City water, as high as 3 parts per million of available chlorine, or 75 pounds of hypochlorite to the million gallons, have been used on raw water. The amount necessary in many instances depends also upon the character of attention given the apparatus.

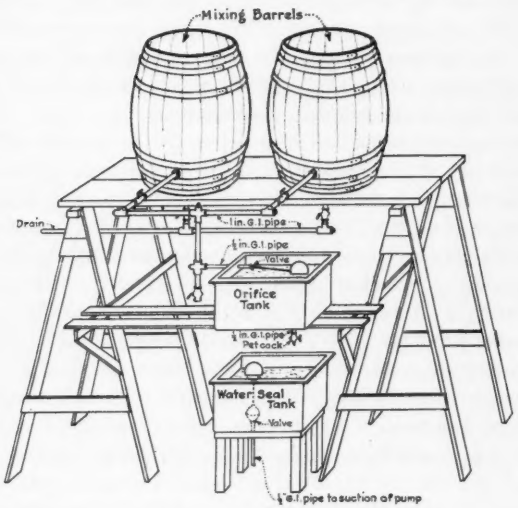
It is by no means a fact that the disinfecting plants in Maryland have been operated with complete satisfaction, for most of them have had trouble of some kind. The difficulties encountered could generally have been avoided with more attention to proper operation. With hypochlorite plants, the principal annoyance has been due to the formation of coatings which clog the pipes; and, where the solution was particularly strong, the materials of which the piping was made have been attacked, necessitating the replacement of parts. These are not serious troubles, however, and can be eliminated by frequent inspection. In the case of liquid chlorine plants, it has been found that occasionally a part becomes corroded and requires replacement, or a valve gets out of adjustment, but the gradual perfection of apparatus is making such occurrences less frequent.

Where faithful and intelligent attention has been given to operation, and the amount of disinfectant used has not been excessive, few complaints have been made regarding tastes or odors in the

water. In one instance, where a liquid chlorine plant of the manual control type was disinfecting water the flow of which fluctuated considerably, there was always an overdose at night which caused complaint due to tastes noticeable during the early hours of the day. This, of course, was the fault of the method employed and not of the treatment itself. In general, fewer complaints have been registered concerning disagreeable tastes where liquid chlorine was used than in the case of hypochlorite.

There has been a marked decrease in the prevalence of typhoid fever in some of the communities where disinfecting plants have been installed. In most cases, however, the period of operation has been so short, and, on account of the small size of some of the places, the appearance of typhoid so irregular, that records do not indicate clearly the effect produced. Moreover, much of the typhoid fever in Maryland is attributable to causes other than impure water supplies. Nevertheless, there are certain well-defined instances where a decrease in typhoid fever morbidity and mortality can be traced directly to purification of a water supply. In Baltimore, the reduction has been very pronounced. After the disinfecting plants were built, the prevalence of typhoid immediately fell off, and the improvement has since continued. In 1915, both the morbidity and mortality rates from this disease, although higher than in many of the larger cities of the country, were approximately half as great as in 1910. Following the introduction into Cumberland of filtered and disinfected water from Evitts Creek, in place of the former raw supply from the Potomac River, the occurrence of typhoid fever was so reduced that, in 1915, there were scarcely more than one sixth as many cases of, and one fifth as many deaths from, this disease as in 1913, in spite of the fact that the corporate limits had been enlarged in the meantime. However, the change in source, and the long storage period provided in the reservoir, would undoubtedly have caused a large proportion of this improvement without the presence of a purification plant. One of the most striking instances of the effect upon typhoid occurrence, caused by disinfecting a water supply in Maryland, was that of the Rockville epidemic, which, after twenty-eight cases had occurred, was checked suddenly by the installation of an emergency hypochlorite plant.

EMERGENCY HYPOCHLORITE PLANT
USED BY MARYLAND STATE DEPARTMENT OF HEALTH
FOR DISINFECTING WATER SUPPLIES



LIST OF MATERIAL

2 – Clean watertight barrels
Several feet of 1 in. and ½ in. galvanized iron pipe and tools for cutting and threading
5 – 1 in. valves
4 – 1 in. "T" branches
1 – 1 in. × ½ in. cross or 4 way fitting
4 – Locknuts to attach 1 in. pipe to barrels
1 – 1 in. cross or 4 way fitting
4 – 1 in. pipe plugs
1 – ½ in. pipe plug
1 – ¼ in. pet cock
1 – Watertight tank, preferably lead lined, with valve, and float control which opens valve as water level drops. An apparatus of this type easily obtained is a flush tank for a toilet.
1 – Lead-lined watertight tank with valve, and float control which closes valve as water level drops. This is necessary only where disinfectant is introduced into suction of pump.

FIG. 2.

In order that prompt remedial measures may be instituted when a water supply is at any time found to be in an unsafe condition,

or when an outbreak of typhoid fever casts suspicion on a water previously untreated, the engineers of the State Board of Health are all instructed in the setting up of an emergency hypochlorite dosing apparatus, making use of ordinary and easily obtainable materials. A sketch showing the general arrangement of the device used, including a bill of material, has been prepared, and is usually sent ahead, so that the necessary material may be on hand when the engineer arrives at his destination. This apparatus, shown on Fig. 2, has proven its value on many occasions, and several of the installations are still in operation.

Basing judgment on experience in Maryland, it may be stated that, where chlorinating plants for water supplies are given faithful and intelligent attention, their use is decidedly a success; and they provide an effective and inexpensive method for treating many water supplies which do not need filtration, as well as for safeguarding those supplies for which filtration, although desirable, is prohibitive. Unfortunately, there seems to have been some tendency among manufacturers to convey the impression that little attention need be paid to the operation of a liquid chlorine plant. This has given the operator the impression, in some instances, that the apparatus can be entirely neglected. While it is true that little or no difficulty need be experienced, except when parts give out, neglect is certain to cause irregularity in dosing, exposure in certain cases to freezing and other undesirable results. Greater efficiency from some of the disinfecting plants in Maryland is to be expected in the future, as the State Board of Health will be enabled to make more frequent inspections than in the past. This will be made possible by the fact that, in addition to the main office of the engineering division, there are maintained four offices in various parts of the state, at each of which there is a resident engineer who has direct supervision over sanitary engineering matters in his district. Without an effective system of control, disinfection would fall short of giving entire satisfaction in connection with many small water supplies.

DISCUSSION.

MR. HARRY W. CLARK.* The disinfection of water by hypochlorite is, of course, an old thing at the present time, and hypochlorite when properly and continuously applied in sufficient amounts is a good disinfectant and kills a very large proportion of of the bacteria in water, especially in clear water. However, in Massachusetts, as you know, most of our surface waters are stored waters, and we depend largely upon storage for purification, although there are quite a number of filters in the state, of one kind or another. I think there are twenty-eight filters in Massachusetts at the present time, and only one place where liquid chlorine or hypochlorite is being used, that place being Wakefield.

We have very little call for the use of disinfectants in connection with water supplies. As you all know, the State Board of Health was changed to a Department of Health rather more than a year and one-half ago, and one of the first orders of the new department was to make and have ready a hypochlorite plant for emergency use, to rush out wherever an epidemic of typhoid fever, due to a polluted water supply, was occurring or was imminent. This plant has been in one of the storerooms of the laboratory for fourteen months without an emergency call of that nature arising, and I trust that it will remain there another fourteen months without being called for.

In a state like Maryland, and in many states where the care and supervision of water supplies is a new thing and where a great many supplies are taken from sources such as described in this paper, I think the use of hypochlorite or liquid chlorine is entirely justified, and I have no doubt it has cut down typhoid fever in places in Maryland. But, as I say, we have had very little use for it in Massachusetts. I have nothing to say against disinfection. When and where it is necessary, I believe in it.

The paper spoke of disinfection by ultra-violet rays, and for the past year and one-half we have had an ultra-violet ray plant in operation at the Lawrence Experiment Station, testing its efficiency with both turbid and clear waters. Judging from the results of our tests, this method of sterilization is more costly

* Chemist, State Department of Health, Boston.

and with us not as efficient as liquid chlorine or hypochlorite. Still, it is an interesting process, and the class of men working upon its improvement will probably lessen its cost and increase its efficiency. I understand that at Ottawa very good results have been obtained from the experiments carried on there, and these results are better than those we have obtained at Lawrence. However, they may have a clearer water. If the water is slightly turbid, the ultra-violet ray seems to have very little efficiency.

I have investigated the use of ozone, and have visited ozone plants abroad and one or two in this country. They seem able to work them abroad successfully, but, I believe, at a considerable expense. At one plant I visited in this country, where it was said ozone was being used and good results obtained, there was a marked odor of hypochlorite around the plant, and evidently it was being used; in fact, I do not think ozone was doing the work, but an abundant supply of hypochlorite was. One could taste it in the water and, as I said, smell it around the plant. This is also a very interesting process, and I hope, as I do in regard to the ultra-violet ray, that it will eventually be more universally successful and of low cost.

EXPERIENCE WITH WOOD PIPES IN NEW HAMPSHIRE.

BY ARTHUR W. DUDLEY.*

[*Read November 10, 1915.*]

Wood pipe for centuries has been in use as a means for conveying water and was one of the earlier materials used for this purpose. The Romans used it for generations, substituting it for the old sheet lead pipes that were used in their first aqueducts. The first water supply of London had lead and wood mains, and the latter eventually replaced all of the lead pipes. Some of their old wooden pipes have been lately removed from the London streets and all were found to be in a perfect state of preservation. In our older American cities, New York, Philadelphia, Boston, Portsmouth, N. H., and others, it was used in their first systems, and at the present day is removed in a perfect state of preservation. The writer has in his office a section dug up in Bowdoin Square in Boston during the excavation for the subway that is as sound as when cut from the forest. It is of solid white oak timber 10 in. outside diameter, of octagonal form, with an inside bore of 4 in. This was a part of Boston's first water system, laid more than two hundred years ago. The water was taken from a pond on Beacon Hill, and was abandoned in 1814, when an extension to the State House occupied the ground covered by this pond.

The writer several years ago saw one of the ancient pipe lines at Portsmouth, N. H., dug up that consisted of pine logs with a 3-in. bore and found the entire line uncovered as sound and in as good condition for conveying water as when laid. This pipe line must have been laid for two hundred years or more. At Exeter, N. H., a wood pipe aqueduct was used up to the installation of their present water system in 1886, and had given good service for nearly one hundred years. These pipes when encountered in street excavations are invariably found to be entirely free from decay. These ancient wooden water pipes were bored logs, and in their manufacture the very best part of the

* Of Dudley & Sawyer, Manchester, N. H.

timber, namely, the heart was removed. It may be asked why, if wood pipe was so durable, should cast iron or any other material be substituted? The answer to that question is that the old method of making a wood pipe limited its inside diameter to the size of the log, and, therefore, large pipes were both expensive and usually impracticable; 6 in. inside diameter was nearly the limit of such pipe. By the modern method of making wood pipe the diameter is practically unlimited, and it has been made in the continuous form up to ten feet in diameter.

The two forms of wood pipe in common use are, the continuous pipe, built of staves, breaking joints, put together in the trench, and what is termed "machine made." This latter is made in lengths from 3 to 14 ft., and shipped to the work ready to be laid. The staves are about 2 in. in thickness, are cut true to the circle of the diameter of the pipe. These staves have two beads upon each longitudinal edge, and two corresponding grooves in the other longitudinal edge. The beads are slightly larger than the grooves and when pressed together the bead crushes into the groove, this making it perfectly watertight. At one end there is a tenon 4 in. long where the staves are one half the thickness of the balance of the walls of the pipe. On the other is a chamber cut 4 in. deep. The tenon is slightly smaller in diameter at the end than at the shoulder so that when driven into the chamber it makes a watertight joint. These staves, cut radially to correspond with the diameter of the pipe, are held together by a steel band, either flat or round, wound spirally upon the pipe by a machine. The high tension of this band forces the beads into the grooves, making a longitudinal joint that cannot leak so long as the elastic limit of the bands is not overcome. After the pipe is wound, and the tenon and chamber cut, it is rolled in a bath of asphalt that adheres to the outside of the steel and wood, protecting them from oxidation. Usually a second coating of asphalt is applied. It is then rolled in a bed of sawdust that forms a protection for it in shipping and handling. It is laid by driving one piece into another until the shoulders are in close contact. This form of pipe is made for diameters from 3 to 36 in.; the larger pipes are made in the continuous form. The eastern manufacturers make their pipes of the best obtainable

Canadian pine. The Pacific Coast pipe is made of Douglass fir and redwood, and is banded with round steel wire instead of flat steel, and differs also in that the pipes are all made with tenon ends, that are connected with sleeves 6 to 8 in. in length. The manufacturers claim that this method of connecting gives greater strength to the pipe line, and also that Douglass fir and redwood is a stronger material than pine. The writer, however, after experimenting with both forms of pipe, came to the conclusion that while the claim that the sleeve method of connection may be stronger, the difficulty in coating the exposed ends of these sleeves, and the fact that they would not be saturated at all times, exposed them to greater danger from decay. Also that while Douglass fir might and probably does possess greater tensile and crushing strength than pine, still its greater brittleness exposes it to more danger from water hammer, and for these and other minor reasons has given the preference to the tenon and chamber, flat hooped pipe. This form of wood pipe was first laid in New Hampshire in 1895 at Penacook, a suburb of Concord, and this system was afterwards connected with and incorporated into the Concord water system. The Antrim water system, constructed in 1896, is a gravity system; its source of supply is Campbell's Pond, some three miles from the village, and the head is slightly over 200 ft. The entire system, both supply and distribution pipes, is of wood. The writer on several occasions during the past few years has uncovered and examined pipes in this water system, and has invariably found them as perfect as when laid; the leakage here, as in all wood pipe lines that he has had to do with, is infinitesimal.

Other water systems, most of them designed and constructed by the writer, are,—Campton Village, where the bead is 186 ft. and the supply pipe 12 in. and 10 in., the distribution pipe, 8 in. and 6 in. in diameter; this was constructed in 1905. Freedom, N. H., constructed in 1912, with a head of 300 ft. Both of these systems have no apparent leaks and have cost next to nothing for repairs since their installation. Bristol, N. H., has a 20-in. wood pipe supply line connecting the village distribution system with New Found Lake, the source of supply. Laconia, N. H., has a wood pipe intake line laid 400 ft. into Lake Winnepesaukee, connecting with

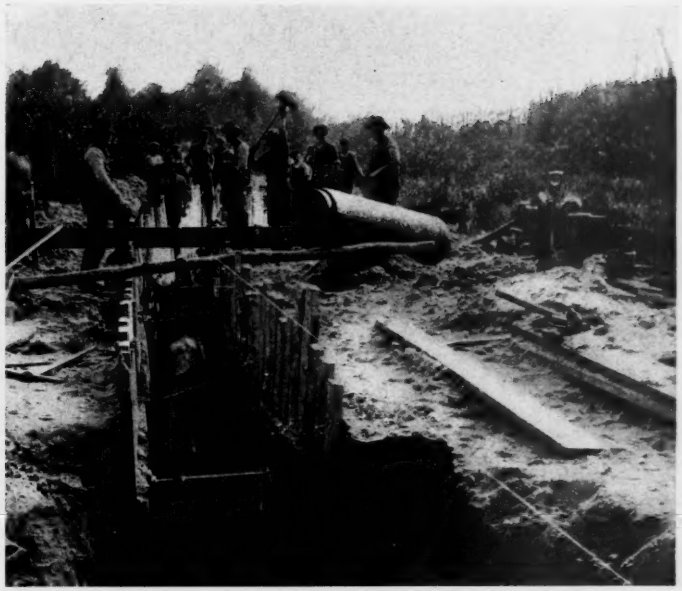
the pumping station. Hudson, N. H., has an 8-in. supply line from Tarnic Pond, and the writer's firm is this season constructing two water systems with wood pipe supply line, one with a four-mile distribution line in a suburban street. The smaller system is at Troy, N. H. The source of supply is a small stream that has its source in the west slope of Mt. Monadnock, and this wood supply line, some four miles in length, is of 12-in. and 10-in. pipe, the head is 310 ft., the distribution system is to be cast-iron pipe. This is now in progress of construction and is about three fourths completed. The wood pipe used is of the Michigan pattern.

The Pembroke water system is a reconstruction and extension of the former Suncock Water Works with a new source of supply. The old system, formerly owned by the Suncock Water Works Company that supplied water to Suncock Village in the town of Pembroke and Allenstown, was never satisfactory, either in the fire service rendered or the quantity or quality of the water furnished, and was acquired in 1914 by the town of Pembroke. In order to secure a satisfactory source it was found necessary to go to Pleasant Lake, fourteen miles distant, in the town of Deerfield, N. H. Lake Pleasant is 316 ft. above the lower level of Suncook Village. The first proposition was to convey the water from the lake to a reservoir nearer the village at a sufficient elevation for a good fire service, but as the pipe line, necessarily following the valley of the Suncook River, would pass through a populous section, including three villages in the town of Epsom, it was decided to draw direct from the lake and supplement the system with the old reservoir of the Suncook system, that had a capacity of three million gallons, for emergencies. This reservoir was not sufficiently high to cover the proposed extension to Pembroke Street, a residential section of the town north of the village. The supply pipe line, 14 miles in length, that is now nearly completed, is laid with 16-in., 14-in., and 12-in. wood stave pipe, and the suburban distribution line in Pembroke Street, four miles in extent, with 8-in. and 6-in. wood pipe. One half this pipe was purchased from the Wyckoff Company, of Elmira, N. Y., and the other half from the Michigan Pipe Company of Bay City, Mich. The saving in first cost under what it would have cost to construct these

lines with Standard cast-iron pipe is slightly over $52 000. One river crossing 110 ft. in length was made with cast-iron pipe. A section where the wood pipe saved considerable expense and difficulty was in the first two miles from the source. Here the pipe was laid through a swampy tract of land; a portion of it was an impassable morass except when the surface is frozen. This two miles was laid in December and January last. The surface at that time was frozen to a sufficient depth to allow teams to pass over it and provide a footing for the pipe layers. At places the flow of ground water was so copious that it required the continual use of a 6-in. Cameron steam pump operating day and night to care for it. The trench required close sheet, piling thoroughly braced. This was laid with 16-in. pipe, and it would have been almost an impossibility to have laid and calked cast-iron pipe in this section. As the lake is elsewhere surrounded by high hills and ridges, this was the only practical place to take a pipe line out of it. This pipe line was laid to a true grade. The bottom of the trench, which averaged about 10 ft. in depth, when the grade did not carry it through the mud or quicksand, was filled with brush and small wood removed from the right of way, the pipe was laid on this and weighted with sand bags, as it could not safely be filled with water until connected with the intake. Considerable difficulty was experienced by the clogging of the pumps first installed with vegetable matter and roots, but after securing the Cameron pump we had no further trouble of this kind. This supply line has been well equipped with both air and vacuum valves.

For the Pembroke Street installation, wood pipe was chosen, mainly for the reason that the Manchester and Concord Electric Railway passes over almost its entire length, and as no provision for a return current is made there, an iron pipe line would undoubtedly have formed this circuit, with the danger of electrolysis imminent. Upon Pembroke Street is located the Pembroke Academy, the Town Hall, several churches, and the best residences in the town. These, however, all have large lots and some extensive grounds so that the services are not very near together.

Ablett & Bowes, of Cohoes, N. Y., are the contractors for this work, and the difficult part of it, consisting of laying the 16-in. pipe through the bog, was done on the percentage plan, and a considerable saving was made in this way.



PEMBROKE WATER WORKS.
LAYING 16-IN. PIPE NEAR INTAKE.

PEMBROKE WATER WORKS.
SETTING GATE VALVE IN 14-IN. WOOD PIPE.

Mr. Frank S. Ablett, of the contracting firm, has been in immediate charge of the work, with Mr. Harry W. Sawyer, the business partner of the writer, as engineer in charge, and much credit should be given both for their constant and unremitting perseverance in pushing it through in the winter months, under constantly recurring difficulties.

The intake at the lake, which extends about 200 ft. into the water, and the gatehouse at its extremity, were completed in January, the ice forming a firm footing and support for the cofferdam used, and making access and delivery of material comparatively easy. Hot water was used in mixing mortar, and a stove inside the gatehouse helped in drying out and preventing freezing. This intake is in about fifteen feet of water, but as the lake at the time of its construction was drawn down to its low water limit, less than one half that depth had to be dammed.

The saving in wood pipe 8 in. and under is not nearly as much as on the larger pipes, and for city or village streets when services are taken off with close frequency should not be recommended.

To sum up the situation, wood pipe has, besides the saving in cost of both pipe and installation, these advantages:

1. It is preserved by water, and not rusted or corroded by it.
2. It is not corroded by any substance, or destroyed by acids or salts.
3. Its carrying capacity is 20 per cent. greater than cast-iron pipe, and remains constant, while that of metal pipe decreases with age.
4. It does not taint or affect fluids going through it.
5. It does not burst if frozen, the elasticity of the wood preventing it.
6. It requires less labor and experience to lay in place than metal pipe, and a considerable saving can be made here.
7. It can, when service pipes are not taken off, be laid in shallower ditches than metal pipe, for it is not so easily affected by frost.
8. In the writer's experience, while more or less joints show slight leakage when the pipe is first filled, they soon swell up and give less trouble in the end than cast-iron pipe.

THE PROPOSED AUXILIARY WATER SUPPLY OF BROCKTON, MASS.

BY ROBERT SPURR WESTON.*

[*Read March 8, 1916.*]

In the annual report of the Water Commissioners of the City of Brockton, Massachusetts, it was stated that, "during the hot, dry season, for several hours a day, and for a number of days, the consumption of water exceeded the capacity of the present main from Silver Lake. This indicates the need of a second main, more storage, or the use of the old supply at times."

The commissioners consulted their chemist and bacteriologist, Mr. George E. Bolling, who reported that by treatment of the water of the older source, namely, the Salisbury Brook Reservoir, with sulphate of alumina, followed by filtration through sand, the color of the water could be reduced to less than that of Silver Lake, the newer source, and used to supplement the present supply when necessary. At the further suggestion of Mr. Bolling, the writer was appointed to report on the general subject of auxiliary water supply, including an outline design of a purification plant should the same be found necessary.

In order to decide whether a second main, more storage, or the utilization of the older supply at times would be advisable, the writer studied with care the various reports of the water commissioners, of the Massachusetts State Board of Health, of Engineers Snow, Felton and FitzGerald, of Superintendent Kingman, and of Chemist Bolling. In addition, the existing sources of supply were examined with Mr. Horace Kingman, chairman of the board. The results of these studies are as follows.

Present Sources of Supply.

The water supply of Brockton dates from 1880, and was drawn first from the Salisbury Brook Reservoir in Avon. This source is

* Of Weston & Sampson, Consulting Engineers, 14 Beacon Street, Boston.

safe from a sanitary standpoint, but, on account of the high color, and vegetable odor and taste of the water, was never an entirely satisfactory supply from the consumer's standpoint. In 1904, the increasing consumption of the growing city exceeded the yield of this reservoir, and on October 12 of the same year the new Silver Lake supply was put into service. This excellent source has now served the city for eleven years, and has a safe yield of 3 500 000 gal. without drawing down the lake materially.

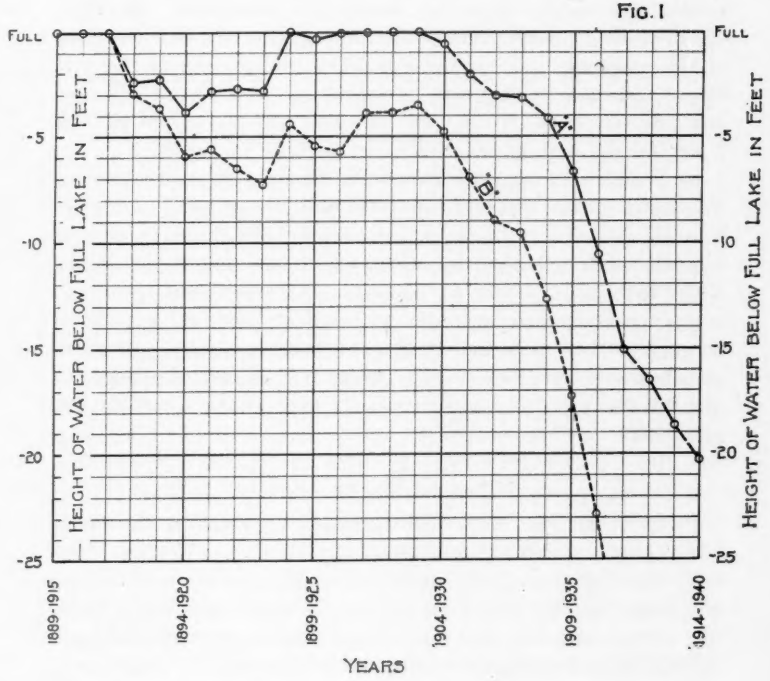
As a source of supply, Silver Lake leaves little to be desired. The water is soft, clear, of low color, and almost free from objectionable odors and tastes. Furthermore, the drainage area is sparsely inhabited, and the reports of the city chemist show the water to be suitable for all purposes. It is delivered by means of two pumps, each having a capacity of 6 000 000 gal. daily, through a 24-in. pipe line 11.62 miles long, discharging into two distributing reservoirs located in Avon and having a total capacity of 8 000 000 gal. The capacity of the pipe line is now 6 000 000 gal. daily.

Yield of Silver Lake.

In 1897, Messrs. Snow and Kingman reported on the Silver Lake supply, as did Messrs. Felton and FitzGerald in 1901. The lake, when full, has an area of 644 acres (*about one square mile*) and a storage capacity of 5 371 000 000 gal. below high-water mark. Mr. Felton estimated that Silver Lake would supply 3 500 000 gal. daily without drawing down the level of the water more than 11 ft. He also estimated that 4 000 000 gal. daily might be obtained by drawing the lake down 20 ft.

Mr. Felton's studies were based on the rainfall records and the Sudbury River run-off records for twenty-five years ending with 1899. Similar studies by us, using the same method, but based on the rainfall and Sudbury records for the twenty-five years ending with 1914, are given in Fig. I. This shows that a draft of 3 500 000 gal. a day would draw Silver Lake down 16 ft. by 1938, while a draft of 4 000 000 gal. would draw it down 16 ft. by 1935. The difference in these two estimates in result is explained by the lower rainfall for the period 1889–1913 than for the period 1875–1899, taken by Mr. Felton.

FIG. 1



BROCKTON WATER WORKS,
BROCKTON, MASS.

HEIGHT OF WATER IN SILVER LAKE 1915-1940
ASSUMING YEARLY YIELDS SIMILAR TO PERIOD 1889-1914

A - AVERAGE DRAFT, 3,500,000 GALLONS PER DAY
B - AVERAGE DRAFT, 4,000,000 GALLONS PER DAY

The following data from the Sudbury River records show the difference between the periods:

DATA FROM SUDBURY RIVER RECORDS.

Average rainfall, 1875–1899	45.83 in.
Average rainfall, 1889–1913	44.99 in.
Average rainfall, 1875–1913	44.99 in.
Average yield, 1875–1899	1 069 720 gals. per day per sq. mile.
Average yield, 1889–1913	976 840 gals. per day per sq. mile.
Average yield, 1875–1913	1 000 000 gals. per day per sq. mile.

It will be noted that the average rainfall for the period 1889–1913 happens to be the same as for the whole period 1875–1913, while that in the period 1875–1899 is 0.84 in. higher.

The average yield of the land surface of the Sudbury River drainage area for 1875–1913 was 1 000 000 gal. per square mile; and on the same basis the 3.4 square miles of drainage area of Silver Lake would yield 3 400 000 gal. per day without drawing upon the storage within the lake. While the rainfall at Silver Lake probably averages slightly less than at Sudbury, the drawn down lake would yield slightly more because of the sandy character of the soil. Therefore it may be stated definitely, as a result of various estimates and experience, that Silver Lake may be depended upon to furnish 3 500 000 gal. without depressing the surface of the lake more than 11 ft.; and 3 830 000 gal. daily without drawing it down more than 16 ft. These seem eminently safe estimates.

EFFECT OF REDUCTION OF STORAGE ON THE QUALITY OF WATER.

The depth 16 ft. has been assumed as the point below which Silver Lake might not be drafted. This is the depth assumed by Mr. Felton, and, with the lake so drawn down, the storage capacity would be reduced one half, as the following table (Felton, 1901 Report, p. 40) shows.

The present excellent quality of Silver Lake is due to the very long storage of the water which enters it. For example, the average colors of the water of Tubbs Meadow Brook and Jones River, the main feeders of Silver Lake, are 1.00 and 1.96, respectively. These colors are reduced to 0.09 by long storage before the water

STORAGE CAPACITY OF SILVER LAKE.

Depth.	Area. Acres.	Storage Capacity. Gallons.
At high water,	644	5 371 361 000
5 feet below high water,	538	4 370 334 000
10 " "	414	3 562 659 000
15 " "	372	2 902 487 000
20 " "	337	2 312 314 000
25 " "	286	1 801 163 000
30 " "	238	1 352 906 000
40 " "	120	606 471 000
50 " "	64	198 215 000
60 " "	21	37 305 000
70 " "	2	

is used. It is obvious, therefore, that any considerable reduction in storage, like 50 per cent., will impair the quality of the water more or less. Furthermore, the writer believes that such a reduction in storage might cause increases in the growths of those organisms which produce objectionable odors and tastes in the water. Some of these organisms, for example, Anabæna, have appeared in Silver Lake from time to time in large enough numbers to be noticed, also numbers of less objectionable organisms like Melosira. The following table, compiled from Mr. Bolling's reports, shows the frequency of occurrence of organisms in the past.

OCCURRENCE OF MICROSCOPICAL ORGANISMS IN SILVER LAKE WATER, 1906–1914.

Year.	No. of Examinations.	No. of Organisms per C.C.		Variations in Organisms per C.C. No. of Counts.				
		Mean.	Median.	Less than 100.	100 to 500.	500 to 1 000.	1 000 to 2 000.	Above 2 000.
1906	45	466	226	5	33	4	2	1
1907	58	222	199	2	34	12	4	6
1908	47	333	274	7	20	8	2	10
1909	41	604	362	4	19	7	6	5
1910	41	431	336	5	25	11	1	0
1911	48	677	358	1	29	13	4	1
1912	47	899	279	5	30	12	0	0
1913	44	866	358	9	25	10	0	0
1914	48	437	185	9	22	10	7	0
Average	47	548	286	5	26	10	3	3

Because about 10 per cent. of the tests show the presence of more than 1 000 organisms per c.c., and objectionable organisms in numbers large enough to be noticeable have been found during the years 1905, 1906, 1907, 1908, 1910, 1911, and 1914, it is not safe to assume that the storage could be reduced one half without at the same time introducing conditions more favorable to growths of objectionable organisms.

Because it requires long storage to reduce the color of the water entering the lake, it seems reasonable that the removal of color would not be so great were the storage reduced one half.

To preserve the excellent character of the water, the lake should be kept as full as practicable. If, in the future, Howard and Pine brooks be diverted to Silver Lake, thereby increasing the supply by 3 390 000 gal. daily, it may be best at the same time to maintain the longer period of storage by increasing the height of the dam at the outlet. Although Silver Lake has a safe yield of 3 500-000 gal. daily, or a higher yield if the storage be drawn upon, it must be supplemented in the not very distant future by other sources. The time when this increase should be made is estimated as follows.

Population.

Until recently, Brockton has grown very rapidly. In 1901 it was estimated by former City Engineer Charles R. Felton that in 1915 the population would be nearly 67 300. Owing to industrial conditions, however, the rate of growth has declined, and the state census for 1915 gives Brockton a population of but 61 944. It is believed, however, that this decline in the rate of increase is not permanent, and the rate of increase will be greater in the future than it has been recently.

Since January 1, 1905, the town of Whitman has been supplied from Silver Lake. The present population of this town is 7 443. At present, water is also furnished to West Bridgwater (population 2 736), to a portion of Hanson (population 600), and to a portion of East Bridgewater (population 210). In addition, connections are now being made to supply a portion of Easton (population 1 000) from the same source.

The future population of Brockton has been estimated by several

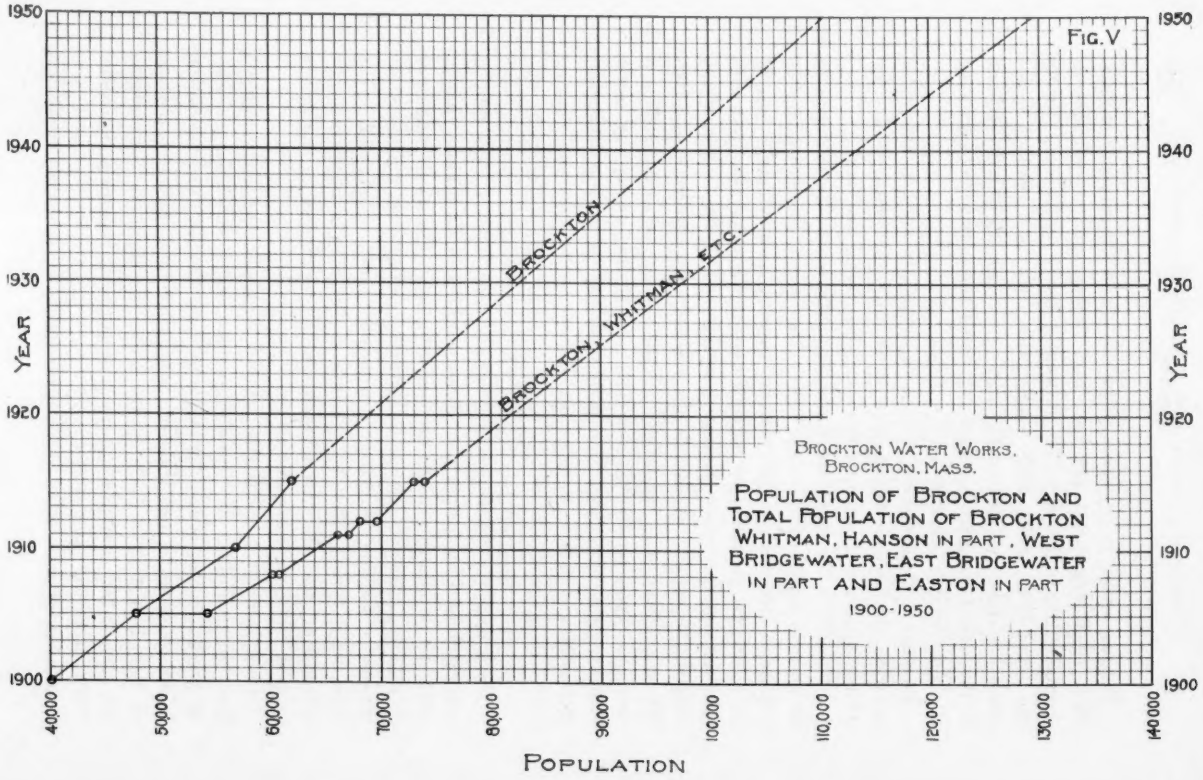


FIG. V
BROCKTON
BROCKTON, WHITMAN, ETC.
BROCKTON WATER WORKS,
BROCKTON, MASS.
POPULATION OF BROCKTON AND TOTAL POPULATION OF BROCKTON WHITMAN, HANSON IN PART, WEST BRIDGEWATER, EAST BRIDGEWATER IN PART AND EASTON IN PART
1900-1950
YEAR
1900
1910
1920
1930
1940
1950
POPULATION
40000
50000
60000
70000
80000
90000
100000
110,000
120,000
130,000
140000

engineers in the past. Their estimates have been examined, revised to conform with the census records which have been made since, and on this basis new estimates have been made, — not only of Brockton but of all the neighboring communities supplied from the Silver Lake source. These populations are given in the following table and are plotted in part on Fig. V.

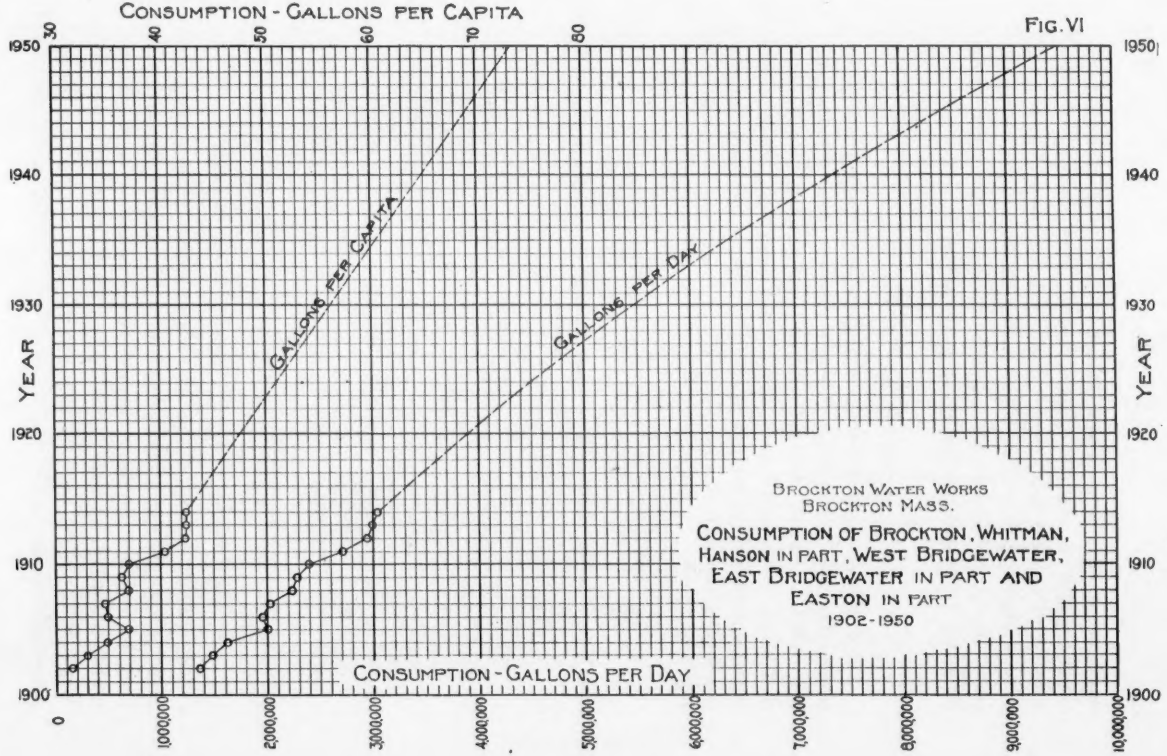
Consumption of Water.

The following table shows the consumption of water in Brockton since 1900, and in Brockton, Hanson, East and West Bridgewater since 1905. It also shows the estimated consumption for the part of Easton, connections with which have just been made. The consumptions are estimated until 1950. Both the total and the per capita consumptions are given in the table, and are plotted on Fig. VI.

Year.	Population.	Consumption.	
		Gallons per Capita per Day.	Total Average Daily.
1900	46 218	29.3	1 354 000
1905	54 315	36.9	2 006 000
1910	64 170	37.0	2 374 000
1915	73 930	43.3	3 201 000
1920	81 720	47.6	3 890 000
1925	89 530	51.9	4 647 000
1930	97 420	56.2	5 475 000
1935	105 360	60.4	6 364 000
1940	113 400	64.8	7 348 000
1945	121 450	69.1	8 392 000
1950	129 450	73.3	9 489 000

Time of Increase in Silver Lake Supply.

Mr. Felton estimated that the consumption of Brockton and Whitman would reach the safe yield of Silver Lake in 1918, and that, by drawing the water down 16 ft., it might be used without addition until about 1930. Since Mr. Felton's estimate was made, West Bridgewater, East Bridgewater, Hanson, and part of Easton have been added to the district supplied. Furthermore, the per


CONSUMPTION - GALLONS PER CAPITA
FIG. VI
30
40
50
60
70
80
1950
1940
1930
1920
1910
1900
YEAR
GALLONS PER CAPITA
GALLONS PER DAY
BROCKTON WATER WORKS
BROCKTON MASS.
CONSUMPTION OF BROCKTON, WHITMAN, HANSON IN PART, WEST BRIDGEWATER, EAST BRIDGEWATER IN PART AND EASTON IN PART
1902-1950
CONSUMPTION - GALLONS PER DAY
0
1000000
2000000
3000000
4000000
5000000
6000000
7000000
8000000
9000000
10000000

capita consumption has exceeded the estimate, as shown by the tables and diagrams accompanying this report. On the other hand, the estimates of future population for Brockton and especially Whitman, made by Mr. Felton, were considerably more than we are able to make at the present time, so that the differences nearly balance one another. They are compared in the following table.

TABLE SHOWING ESTIMATED WATER CONSUMPTION OF THE BROCKTON WATER DISTRICT.

Year.	PER CAPITA CONSUMPTION. GALLONS PER DAY.		TOTAL CONSUMPTION. GALLONS PER DAY.	
	Felton's Estimate. (1901.)	Present Estimate. (1915.)	Felton's Estimate. (1901.)	Present Estimate. (1915.)
1915	39	43	3 042 000	3 201 000
1920	41	48	3 788 400	3 890 000
1925	43	52	4 635 400	4 647 000
1930	45	56	5 625 000	5 475 000
1935		60		6 364 000
1940		65		7 348 000
1945		69		8 392 000
1950		73		9 489 000

It is obvious that the draft from Silver Lake will exceed the average yield of the drainage area by 1918, just as estimated by Mr. Felton, and that by drawing from storage the lake may possibly be used until the dates given in the following table.

TABLE SHOWING TIMES WHEN ESTIMATED WATER CONSUMPTION WOULD EQUAL THE YIELD OF SILVER LAKE, PLUS THE STORAGE, WHEN DRAWN TO VARIOUS DEPTHS BELOW HIGH WATER.

(Based on Average Yield of Silver Lake.)

Year.	Consumption. Gallons per Day.	Depression of Water Level. Feet.
1919	3 743 000	1
1922	4 183 000	5
1925	4 647 000	10
1927	4 968 000	15
1928	5 137 000	20

In the light of the above evidence, it would seem wise to supplement Silver Lake not later than 1927, in order to meet the average consumption — perhaps earlier if increased draft causes the quality to deteriorate.

RELATION OF MAXIMUM CONSUMPTION TO AVERAGE CONSUMPTION.

While Silver Lake alone might supply the average amount of water required until 1927, the maximum daily amount must be furnished also. During the past year, the maximum daily consumption has at times exceeded 6 000 000 gal. daily, or more than the designed capacity of the pipe line from Silver Lake. To pump 6 000 000 gal. in twenty-four hours through the present 24-in. pipe line means pumping against a friction head of 102 ft. As the pipe gets older, the friction head will increase, as estimated in the following table.

TABLE SHOWING INCREASE IN FRICTION HEAD IN THE 24-INCH SILVER LAKE PIPE LINE, DUE TO AGE.

(Based on Hazen and Williams Hydraulic Tables.)

Year.	Friction Head in Feet at Pumping Rate of 6 000 000 Gal. Daily.	Volume of Water which may be Pumped Daily without increasing the Present Friction Head above 102 Ft.
1904	74.9	6 805 000
1910	89.6	6 355 000
1915	101.9	6 000 000
1920	113.6	5 660 000
1925	126.5	5 340 000
1930	140.0	5 055 000
1935	153.5	4 800 000
1940	166.0	4 575 000
1945	180.8	4 390 000
1950	194.4	4 235 000

Not only has the maximum daily consumption reached the capacity of the Silver Lake pipe line, but during the summer of 1914 there were times during certain days when the district was using water faster than it was pumped from Silver Lake. This was possible by drawing from the two concrete distributing reservoirs in Avon. These have a capacity of only 8 000 000 gal., and should

the period of maximum consumption be greatly prolonged, or a severe fire occur during this period, a shortage of Silver Lake water would be liable to occur. The possibility of this shortage was foreseen by Mr. Felton in 1901, and he believed that when it occurred the present Salisbury Brook Reservoir would serve as an auxiliary, although he states that " it is a grave question whether public opinion would sanction the use of a poorer water, still it seems only fair that those sources should be considered as an auxiliary to Silver Lake. . . . At this time, if it were deemed advisable, it might be used in connection with filtration."

Quality of Salisbury Brook Reservoir Water.

During the past few years, when attempts have been made to use water from the Salisbury Brook Reservoir as an auxiliary source of supply, serious complaints have arisen on account of the color of the water, which averages 0.52, while the color of the Silver Lake water is only 0.09. This means that on many streets, particularly in the northern part of Brockton, the water in a certain house might be alternately high and low colored, — that is, alternately disagreeable and agreeable.

The color of the water has varied since 1887, as shown by the analyses of the Massachusetts State Board of Health, which are tabulated on the following page.

When the reservoir was constructed, neither the vegetation nor the soil were removed by stripping, and during the first years the color of the water was very much higher than subsequently, the average color for the first five-year period being 0.78, for the last five-year period 0.51. In 1889 the color of the water reached 1.30, but during the last five years the maximum was 0.84, and during the same period the minimum color was 0.23, as low as it has ever been. Generally speaking, the water has improved with time.

As recommended by Mr. Felton in 1901, the Salisbury Brook Reservoir has been maintained as a possible future auxiliary source. The reservoir has been kept in good condition, and careful supervision has protected the water against pollution. It is, therefore, safe to use, but it is absolutely necessary, in order to make this supply available as an auxiliary, that it be decolorized. Were its disagreeable characteristics removed by purification, it would be

COLOR OF WATER FROM SALISBURY BROOK RESERVOIR.
1887–1914.

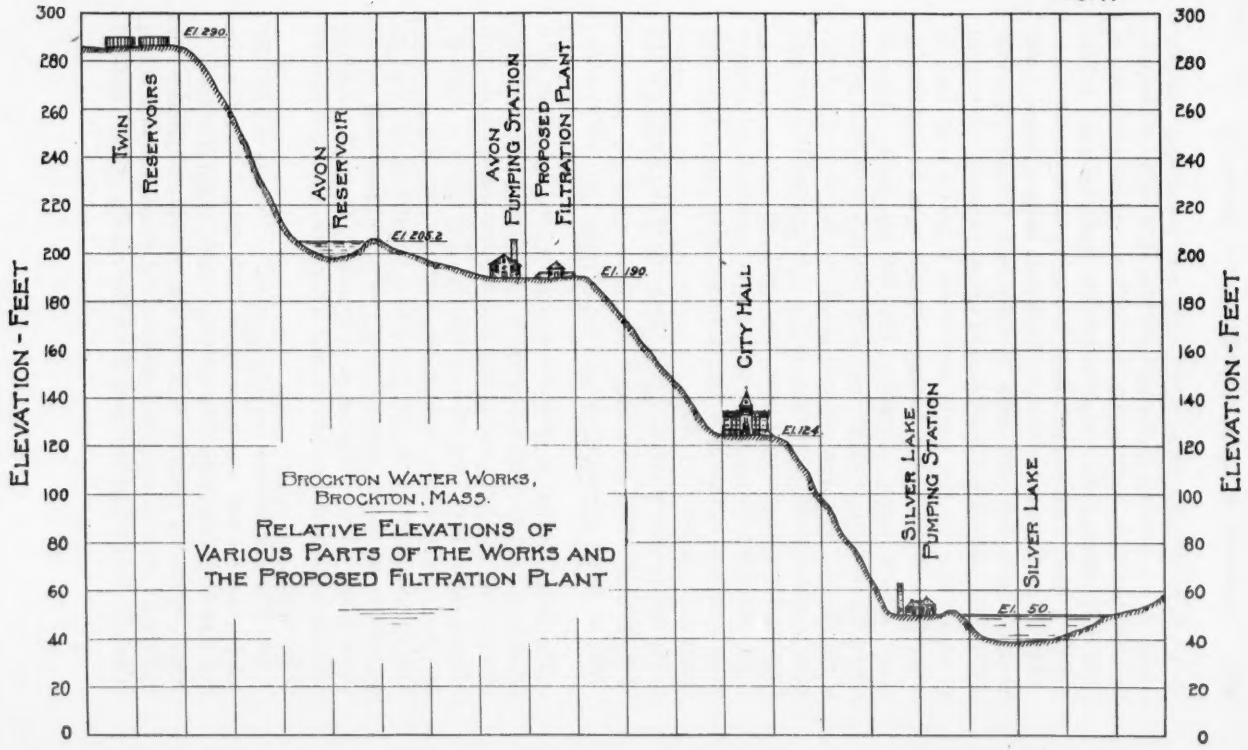
Year.	Color of Water.		
	Annual Average.	Maximum.	Minimum.
1887	.98	1.2	.8
1888	.76	1.1	.45
1889	.78	1.3	.4
1890	.75	1.0	.45
1891	.62	.90	.40
1892	.55	.80	.30
1893	.67	.90	.60
1894	.81	.95	.68
1895	.80	1.10	.52
1896	.64	1.00	.40
1897	.85	1.03	.60
1898	.73	.98	.50
1899	.48	.77	.32
1900	.57	.75	.36
1901	.62	.96	.46
1902	.49	.65	.27
1903	.51	.63	.33
1904	.55		
1905	.50	.71	.37
1906	.54	.70	.37
1907	.51	.66	.36
1908	.46	.75	.23
1909	.54	.70	.34
1910	.49	.76	.25
1911	.41	.60	.23
1912	.64	.84	.35
1913	.51	.75	.30
1914	.51	.65	.25

practically as agreeable a supply as Silver Lake, besides being an available auxiliary to supply the city during conflagrations, or during other periods of abnormal consumption, or should a break in the Silver Lake pipe line occur. It would postpone the time when it would be necessary to add to the Silver Lake supply.

YIELD OF SALISBURY RESERVOIR.

The old reservoir in Avon has an area of approximately 92 acres with the flashboards in place on the dam, and the catchment area supplying the reservoir is 3.11 square miles. The average total yield of the Salisbury Brook source is 3 110 000 gal. daily, or about

FIG. II


ELEVATION - FEET
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TWIN RESERVOIRS
EL 290.
AVON RESERVOIR
EL 208.2
AVON PUMPING STATION
PROPOSED FILTRATION PLANT
EL. 190.
CITY HALL
EL 124.
SILVER LAKE PUMPING STATION
SILVER LAKE
EL. 50.
BROCKTON WATER WORKS,
BROCKTON, MASS.
RELATIVE ELEVATIONS OF
VARIOUS PARTS OF THE WORKS AND
THE PROPOSED FILTRATION PLANT

92 per cent. of that of the Silver Lake catchment area, but the storage in the reservoir is only 309 291 000 gal. at high-water mark, as compared with 5 371 361 000 gal. in Silver Lake. Because of the smaller storage, this supply cannot be depended upon to furnish more than 1 500 000 gal. daily in a dry year.

The value to Brockton of the old reservoir as an auxiliary is far beyond what it will yield safely in a dry year. Much larger volumes than 1 500 000 gal. daily may be drawn from this reservoir in an emergency. If this source were used, it would seem best to provide a purification plant having a capacity equal to the capacity of the present pump, — namely, 5 000 000 gal. daily. The old reservoir, when full, would furnish 5 000 000 gal. daily for a period of thirty-eight days beginning in the driest month of the driest year, or one hundred nine days on the average, and this without drawing down the reservoir more than eight feet.

The Salisbury Brook Reservoir has other practical advantages as an auxiliary, in that it is 155 ft. higher than Silver Lake and eleven miles nearer City Hall.

The relative elevations of the various parts of the works and the proposed filters are shown on Fig. II.

Best Method of Color Removal.

The usual method of color removal is to treat the water with sulphate of alumina, which immediately reacts with the water and, after storage for from one to three hours, forms a precipitate with which a large part of the color combines. The degree of color removal is controlled by varying the dosage of applied chemical. The alumina added with the chemical is completely removed by subsequent filtration, either through slow or rapid sand filters; the sulphate added displaces an equivalent amount of carbonate with the formation of carbon dioxide, a harmless gas which remains in the water.

Slow filters in this case could be operated at the rate of 6 000 000 gal. per acre per day, and to decolorize 5 000 000 gal. would require one acre of filter surface. In addition, there would have to be a large coagulating basin in order to remove by precipitation the major part of the precipitated sulphate of alumina and color, which otherwise would clog the slow filter too rapidly. The modified

slow filter plant as just outlined would cost over $135 000, exclusive of the additional land which would be required.

The treated water could be filtered through rapid filters at a rate of 125 000 000 gal. per acre per day, after passing through a coagulating basin holding the equivalent of two or three hours' flow. Less chemical would be required than with slow filters. This plant could be located for the most part on the existing pumping station lot, as shown by the sketches accompanying this report.

Considerations which Govern the Choice of Method.

The slow filter, without chemicals, is best adapted to the purification of slightly turbid and slightly colored waters which are subject to sewage pollution. A slow filter is easier to operate than a rapid filter. On the other hand, slow filters are not suited to the decolorization of water or the purification of waters containing large amounts of suspended matter, unless the water be first treated with chemicals, followed by subsidence. Slow filters to treat colored waters were installed at Philadelphia (Torresdale), Albany, and Springfield, and in the beginning operated without the aid of chemicals, but it has since been found necessary in these cities to pre-treat the raw water with chemicals in order to obtain satisfactory results.

Rapid filters are best adapted to the purification of waters containing a color of more than 0.20 or a turbidity of more than three parts per 100 000. On the other hand, they must be operated carefully in order to secure the best results. One of the difficulties in operation is to properly dose a water which changes its character rapidly, making necessary rapid changes in the dose of chemicals. Waters which are drawn from reservoirs, however, are not apt to change rapidly in character.

Inadequacy of Purification without the Addition of Chemicals.

The use of a slow filter without coagulants, even at a rate as slow as 3 000 000 gal. per acre per day, would effect the removal of only about 40 per cent. of the coloring matter. That is, the present average color of the Salisbury Brook Reservoir water, 0.52, would

be reduced to an average of 0.31, or about three times that of Silver Lake. At times of high color the filtered water color would exceed 0.50. It would be folly to go to the greater expense of slow filters ($100 000 as compared with $70 000) and then produce a filtered water three times as highly colored as Silver Lake. It would mean that on certain streets the water would vary in color from hour to

TABLE SHOWING AMOUNTS OF COLOR REMOVED BY DIFFERENT METHODS OF WATER PURIFICATION.

By Slow Filters, without Preliminary Treatment.

City.	Year.	Color.						Authority.
		Raw Water.			Filtered Water.			
		An. Av.	Max.	Min.	An. Av.	Max.	Min.	
Lawrence, Mass....	1913	.33			.18			M. S. B. of H.
Athol, Mass.....	1913–14	.84	2.20	.30	.50	1.15	.18	J. L. Tighe
Providence, R. I....	1912	.49	.67	.35	.29	.42	.20	R. I. S. B. of H.
Pittsburg, Pa.....	1912	.047	.07	.03	.03	.05	.02	An. rep., City P.
Hudson, N. Y.....	1910–11	.17	.30	.10	.08	.15	Trace	N. Y. S. B. of H.
Poughkeepsie, N. Y.	1911	.31	.40	.25	.24	.30	.20	N. Y. S. B. of H.
Yonkers, N. Y.....	1911	.12	.15	.10	.05	.10	Trace	N. Y. S. B. of H.
By Slow Filters, with Preliminary Treatment.								
So. Norwalk, Conn.	1909	.29	.60	.19	.09	.15	.05	C. S. B. of H.
Torresdale, Philadelphia, Pa.	1914	.15	.19	.12	.10	.12	.08	F. D. West
By Rapid Filters, with Chemical Treatment.								
Elmira, N. Y.....	1913	.15	.30	.08	.01	.05	Trace	N. Y. S. B. of H.
Cohoes, N. Y.....	1913	.22	.33	.12	.08	.12	Trace	N. Y. S. B. of H.
Rensselaer, N. Y....	1913	.26	.40	.15	.02	.05	Trace	N. Y. S. B. of H.
Binghamton, N. Y..	1911	.11	.15	Trace	.03	.10	Trace	N. Y. S. B. of H.
Little Falls, N. J....	1912	.46	.92		.08	.22		F. W. Greene
Minneapolis, Minn..	1914	.49			.18			Plant record
Wilkinsburg, Pa....	1914	.28			.00			J. M. Caird
Exeter, N. H.....	1913	.30	.85	.10	.06	.25	.02	R. S. W.
Biddeford, Me.....	1915	.11	.33	.02	.04	.20	.00	R. S. W.
Arlington Mills, Lawrence, Mass..	1915	1.31	1.75	.80	.16	.20	.10	R. S. W.
E. Greenwich, R. I..	1912	.43	.78	.18	.04	.10	.02	R. I. S. B. of H.
E. Providence, R. I.	1912	.60	1.50	.30	.06	.13	.02	R. I. S. B. of H.

hour and from day to day, as the supply would be drawn from Silver Lake or the Salisbury Brook Reservoir. This would not suit the consumers. By the use of chemicals, however, the color can be reduced to less than 0.10, less than the color of Silver Lake water.

In confirmation of this opinion, the writer would offer the preceding table, showing the average, maximum, and minimum colors of the raw and filtered water supplied to several cities. This table shows that single slow filters without chemical treatment remove on the average 40 per cent. of the color, that double filtration without coagulating chemicals removes 57 per cent., whereas 82 per cent. of the color is removed by rapid filters with chemical treatment.

Single, slow filters which remove the larger percentages of color without chemicals usually operate with river waters or those having the coloring matter in a semi-suspended state. With the comparatively clear reservoir or settled waters they are least efficient.

Effect of Chemical Treatment on Hardness.

Salisbury Reservoir water would require the addition of about thirty parts of sulphate of alumina per million in order to decolorize it. To absolutely prevent any increase in the hardness, and to make sure that no undecomposed chemical passes the filter, there must be present in the water alkali enough to completely precipitate the chemical. The natural alkalinity of the water is hardly sufficient, and therefore it will be necessary to add to the water about eight parts of alkali, in the form of soda, per million, before the addition of the sulphate of alumina. At Exeter, N. H., no alkali is added, yet the hardness increases very slightly (from 2.73 to 3.03 parts per 100 000). This slight increase in hardness may be avoided by the addition of alkali.

Best Filter for Brockton.

The writer holds no brief for one filter or the other, but, to decolorize the Salisbury Brook water, chemicals must be used, and chemicals can be used most economically and efficiently with a rapid filter, properly designed, constructed, and operated.

Distributing Reservoirs.

Distributing reservoirs are necessary for meeting emergencies, and, if large enough, may be used to overcome the discrepancies between average and maximum consumptions. The two Avon reservoirs will hold one day's maximum supply until the average consumption reaches 4 000 000 gal. daily. It is necessary that one day's supply be available at all times for emergencies, but to insure this the source must be able to supply water faster than it is used on days of largest consumption. If, for example, the maximum consumption exceeds the capacity of the pipe line for several days in succession, as it has and will, the reserve in the reservoirs will be gradually destroyed and the emergency which they are designed to meet (such as a break in the Silver Lake pipe line or a bad fire) may occur when they are drawn down too far to be of service.

The maximum consumption, also, might be met by the construction of reservoirs. Unfortunately no good natural sites for the construction of a large distributing reservoir at a sufficient elevation exist near Brockton. Consequently artificial reservoirs would have to be used. The two excellent concrete reservoirs which the city now owns are as economical as could be built, and cost $10 000 per million gallons capacity. Consequently the cost of storage to furnish a supply of 5 000 000 gal. daily for varying times would be the amounts shown in the following table.

Cost of Reservoirs for Furnishing 5 000 000 Gallons Daily for Various Periods.

Time.	Capacity. Gallons.	Cost.
1 day	5 000 000	$50 000
2 days	10 000 000	100 000
5 days	25 000 000	250 000

Reservoirs costing the same as an additional 24-in. main ($345-000) would store only seven days' supply, and those costing as little as a purification plant ($70 000) would store only one and one-half day's supply.

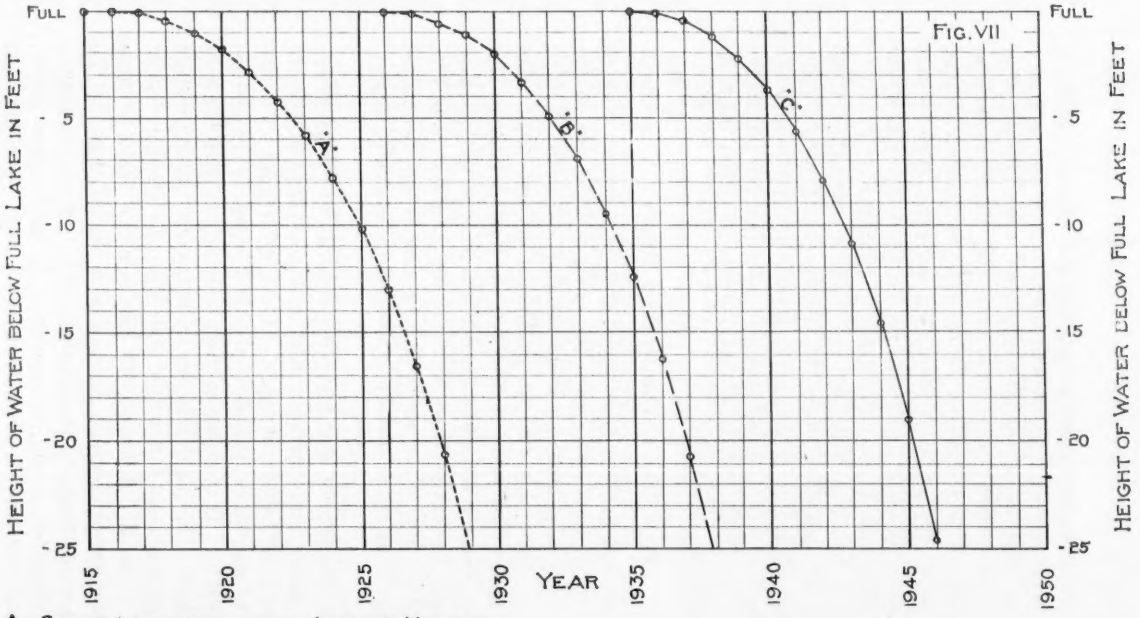
New distributing reservoirs of 4 000 000 gal. capacity ought to be added to the supply from time to time, to store the necessary one day's consumption at the maximum rate. If a new pipe line be installed, no new reservoir need be built until 1921. If the pipe line be postponed and Salisbury Brook water be purified, so that both sources of supply may be used when necessary, the construction of more distributing reservoirs may be postponed until a new pipe line larger than 24 in. in diameter is required.

Because of their very high unit cost, and because either of the other methods suggested meets the deficiencies of supply more liberally and efficiently for the same expenditure, and because the present reservoirs store enough water to meet the emergencies for which they were built, the construction of new reservoirs would be neither timely nor expedient.

Pipe Line *v.* Purification Plant.

A new pipe line to Silver Lake would give the necessary relief to the city until at least 1927, when the Silver Lake source should be supplemented in order to avoid drawing below 16 ft. The best way of doing this may be determined at that time. The present evidence is in favor of diverting the flow of Howard and Pine brooks, which would add 3 390 000 gal. daily to the quantity which might be drawn from Silver Lake. Further additions might be made from other ponds and streams in the vicinity of Silver Lake, as reported previously (Snow and Kingman, Report, 1897).

However, the present pipe line has a capacity of 6 000 000 gal. when the pumps are working against a friction head of 102 ft., while Silver Lake has an average yield of 3 500 000 gal. The capacity of the pipe line is, therefore, greatly in excess of the average yield of the lake. It therefore seems unwise, apart from financial considerations, to lay a new pipe line simply to serve as an auxiliary when the present main can deliver more than the average yield of the lake. If the line were laid, the pipe capacity would be more than doubled for the present, decreasing as the lines aged. The two mains would supply the city until 1931, when a third main, 30 in. in diameter, would be required. It would seem better, therefore, to postpone the construction of a 24-in. pipe line until



A - Silver Lake alone at an Average Yield of 1,000,000 Gallons per Day per Square Mile

B - Silver Lake at 1,000,000 Gallons per Day per Square Mile and Avon Reservoir at 1,500,000 Gallons per Day.

C - Silver Lake at 1,000,000 Gallons per Day per Square Mile and Avon Reservoir at 1,000,000 Gallons per Day per Square Mile.

Brockton Water Works
Brockton, Mass.

Height of Water in Silver Lake by Years with Consumptions as Estimated
1915-1950

Silver Lake has to be added to, when a larger pipe line (36-in.) should be laid, taking the place of the two smaller mains which the other plan would demand, and effecting a great saving in cost. Meanwhile, the deficiencies should be made up with purified Salisbury Brook Reservoir water.

It is obvious that if the construction of the inevitable additional pipe line be postponed, say until 1931, it would be practicable to lay a pipe as large as 36 in. in diameter, which, with the present 24-in. line and the Salisbury Brook filters, would supply the Brockton District to the probable capacity of both sources, increased by probable additions to Silver Lake. By adding other sources to Silver Lake, a new 24-in. pipe line would serve as an auxiliary until 1931. So would the old source if some of the "large amount of water now going to waste in the winter and spring" be used in addition to the dry weather yield of the reservoir, as recommended by Mr. Felton, to reinforce the Silver Lake supply, as shown on Fig. VII.

The future supply would be much more flexible if taken from two sources than from one alone. With the old supply available as an auxiliary, a break could occur in the Silver Lake line and the various quantities of water could be supplied from the old source for the times given in the following table.

QUANTITIES OF PURIFIED WATER WHICH COULD BE SUPPLIED FROM SALISBURY BROOK RESERVOIR AND PRESENT DISTRIBUTING RESERVOIRS, SHOULD AN ACCIDENT HAPPEN TO THE SILVER LAKE PUMPS OR PIPE LINE.

Gallons per Day.	Number of Days.
5 000 000	Not less than 38
6 000 000	8
7 000 000	4
8 000 000	2.7
9 000 000	2.0
10 000 000	1.6
11 000 000	1.3
12 000 000	1.1
13 000 000	1.0

The quantities in the above table would be ample until an additional pipe line to Silver Lake would be needed. Another advan-

tage of the Purification Plan is that Silver Lake would last at least four years longer and without using more than the dry weather yield of the old source.

Experience has shown that the hygienically safe Salisbury Brook water can be made attractive; furthermore, it is a convenient auxiliary and is also more economical than a new 24-in. pipe line.

A comparison of the two programs is given in the following table. In this table, it is assumed that Silver Lake may be drafted 16 ft. without injuring the quality of the water. Should this assumption prove incorrect, additions to Silver Lake would have to be made earlier than the dates given.

COMPARISON OF PROGRAMS NECESSITATED BY TWO METHODS OF AUXILIARY SUPPLY, ASSUMING SILVER LAKE TO BE DRAWN DOWN 16 FEET AND ONLY THE DRY WEATHER FLOW OF SALISBURY BROOK RESERVOIR UTILIZED.

Year.	24-In. Pipe Line Plan.	Purification Plan.
1916	24-in. pipe line, $345 000.	Purification plant, $70,000.
1917		
1918		
1919		
1920		
1921	New reservoir.	
1922		
1923		
1924		
1925		
1926		
1927	Additions to Silver Lake.	
1928		
1929		
1930	30-in. pipe line and pump.	36-in. pipe line and pump.
1931		Additions to Silver Lake.
1932		
1933		
1934		
1935		
1936		New reservoir.

FINANCIAL CONSIDERATIONS.

The first cost of a new 24-in. pipe line is estimated at $345 000; of a purification plant having a capacity of 5 000 000 gal. daily, at

$70 000. The interest and sinking fund charges during the life of the bonds, and beginning 1917, may be estimated as follows:

	24-In. Pipe Line.	Purification Plant.
Interest, 4 per cent	$13 800	$2 800
Sinking fund payments, basis 3.75 per cent.	6 180	1 254
Total annual fixed charges	$19 980	$4 054

These estimates, capitalized at 4 per cent. interest for eleven years, — the end of the period during which it is estimated that Silver Lake will furnish enough water to supply the average consumption of the district, — will amount in 1927 to the following:

Accumulated Value of Fixed Charges, 1927.

	24-In. Pipe Line.	Purification Plant.
Value of fixed charges	$280 234	$56 860
Less value of purification plant	56 860	
Difference in favor of purification plant	$223 374	

Cost of Water.

The cost of pumping water from Silver Lake may be compared with the cost of purifying and pumping the Salisbury Reservoir water, as follows:

Cost of pumping from Silver Lake, based on 1912, 1913, and 1914 records	$13.09 per million gal.
Cost of operation of purification plant and old pumping station:	
Coal	$1 950.00
Wages	2 000.00
Oil and waste	100.00
Repairs and miscellaneous	300.00
Per annum	$4 350.00

Per 1 000 000 gal.	$7.96
Chemicals per 1 000 000 gal.	5.01
Wash water at $9.00 per 1 000 000 gal.	.36
Superintendence	.55
Light and heat	.20
Repairs	.25
Total per 1 000 000 gal.	$14.33
Additional cost of Salisbury Brook Reservoir supply, purified and pumped	$1.24 per mil. gal.
Additional annual cost of purifying 1 500 000 gal. daily	$678.90
In eleven years, the extra cost capitalized at 4 per cent. would be equivalent to	$9 525.00

SUMMARY OF COST.

Cost of pipe line, 1927		$280 234.00
Cost of filters to 1927	$56 860.00	
Cost of filter operation and pumping at Brockton, to 1927, additional	9 525.00	
Total cost of filters and operation, to 1927		66 385.00
Saving over pipe line by 1927		$213 849.00

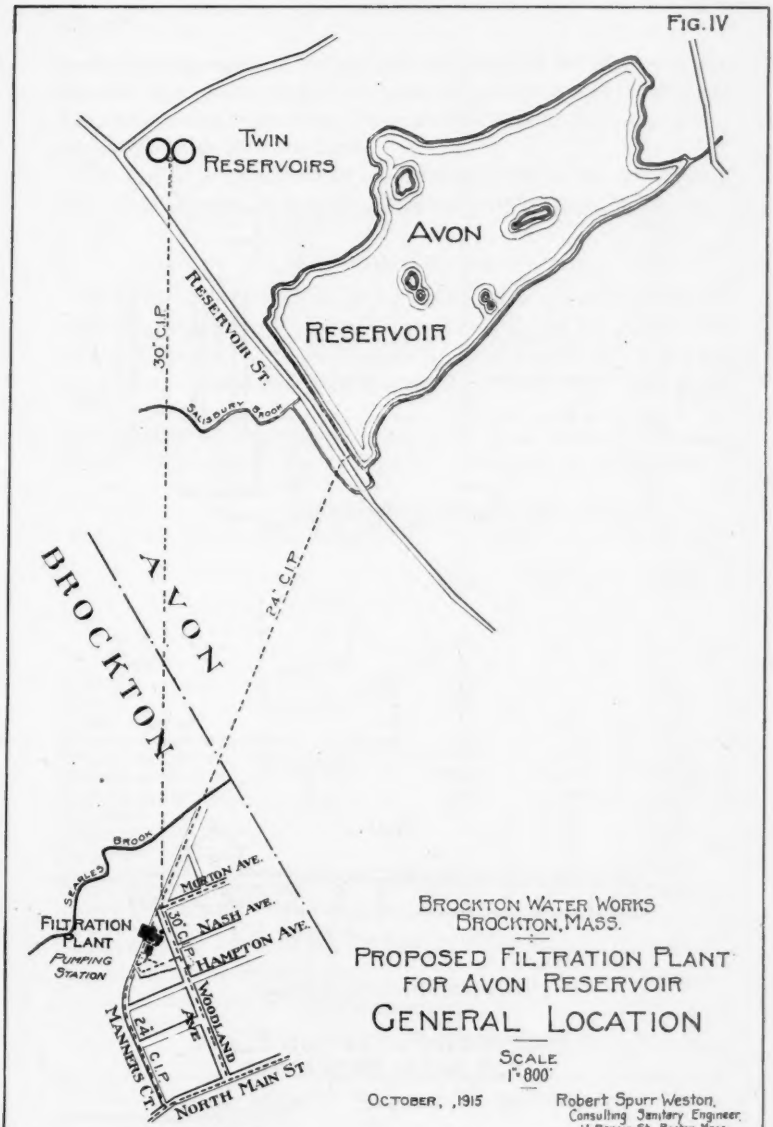
LOCATION AND DESIGN OF PURIFICATION PLANT.

Figs. IV and III illustrate the proposed filtration plant for the Salisbury Brook Reservoir, which would be located on the old pumping station lot along the pipe line leading from the Salisbury Brook Reservoir.

The plant would consist of a coagulating basin having a capacity of 500 000 gal.; five filter units each having a capacity of 1 000 000 gal. daily, which would be arranged on both sides of a gallery which would contain the necessary filter piping and appurtenances; an elevated tank for the storage of wash water; a house to cover the operating room of the filters and to house the devices for applying chemicals to the unfiltered water, and a filtered water basin having a capacity of 500 000 gal., from which the present pumps would discharge the filtered water into the mains.

As the water came from the reservoir, it would receive a dose of chemicals; the treated water, after storage in the coagulating basin, would pass through the filters into the filtered water basin;

FIG. IV



BROCKTON WATER WORKS
BROCKTON, MASS.

PROPOSED FILTRATION PLANT FOR AVON RESERVOIR

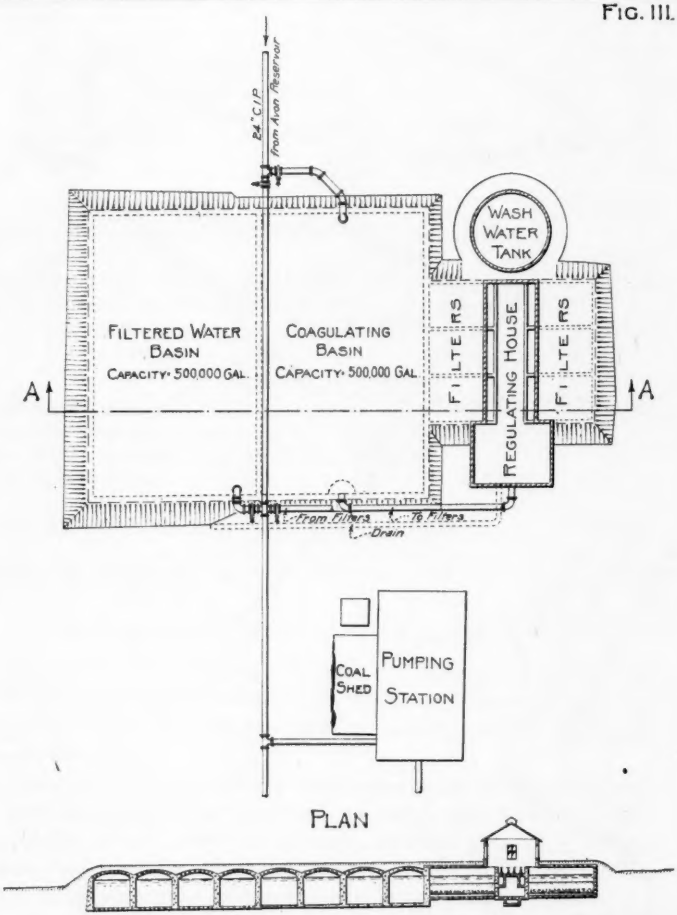
GENERAL LOCATION

SCALE
1" = 800'

OCTOBER, , 1915

Robert Spurr Weston,
Consulting Sanitary Engineer,
14 Beacon St. Boston, Mass.

FIG. III.



BROCKTON WATER WORKS,
BROCKTON, MASS.

PROPOSED FILTRATION PLANT FOR AVON RESERVOIR

OCTOBER, 1915 SCALE 1"=40'

Robert Spurr Weston,
Consulting Sanitary Engineer,
14 Beacon St, Boston, Mass.

a small pump would lift about four per cent. of the filtered water into the wash water tank, from which the filters would be washed; the waste water containing the material washed from the filters would discharge into the drain.

No new or untried devices are contemplated in the design, but only what experience in other places has proved to be successful.

Practical Results.

As an example of what might be reasonably expected as a result, there is appended to this report a table showing the results obtained at Exeter, N. H. (during 1914), by a plant constructed by the writer in 1906, and consequently ten years old. This plant

Average Results of Analyses of Salisbury Brook Reservoir Water, 1910–1914, inclusive; also of Exeter, N. H., Reservoir Water, before and after Purification, for Year 1914.
(Parts per 100 000.)

Source.	Salisbury Brook Reservoir.	Exeter Water Works Reservoir.	Exeter Filtered Water.
Odor {Hot	Ft. veg.	3.3–veg.	2.1–veg.
Odor {Cold	Dec. veg.	1.3–veg.	0.1–veg.
Turbidity	V. slight	1.5	0.19
Color	0.52	0.56	0.07*
Oxygen consumed	.71	0.653	0.278
Nitrogen as free ammonia	.0032	0.0078	0.0099
Nitrogen as albuminoid ammonia	.0256	0.0307	0.0140
Nitrogen as nitrites	.0000	0.0000	0.0001
Nitrogen as nitrates	.0009	0.0054	0.0060
Chlorine	.47	0.547	0.572
Alkalinity	. . . .	1.67	0.95
Hardness	1.10	2.73	3.03
Iron	.038	0.049	0.013
Total residue on evaporation	4.54	7.56	7.26
Bacteria per c.c. at 20 degrees C.	.....	293.	27.
Bacteria per c.c. at 37.5 degrees C.	.....	139.	7.
Bacillus coli in 10 c.c.	.....	None	None
Presumptive test for B. coli in 10 c.c.	.....	{37% Positive	Negative
Authority	Mass. St. Bd. of H.	R. S. W.	R. S. W.

* Experiments by Mr. Bolling show that the color of the Salisbury Brook Reservoir water may be reduced to 0.04.

treats a very bad water from a shallow reservoir. The conditions are worse than at Brockton, yet the color of the filtered water is reduced below that of Silver Lake.

Summary and Conclusions.

The present water supply from Silver Lake is excellent in quality. It is delivered through a pipe line 11.6 miles long, against a head of 340 ft. The present capacity of this pipe line is 6 000 000 gal., and is exceeded at times of maximum consumption. Either more distributing reservoirs or a new pipe line must be constructed, or the old Salisbury Reservoir must be used as an auxiliary.

The continuous average yield of Silver Lake is 3 500 000 gal. daily. The present population of Brockton, according to the state census, is 61 944; and the average daily consumption of water is about 3 201 000 gal. As reported by other engineers, the average consumption will exceed the average yield of Silver Lake by 1918, but by drawing down the lake 16 ft., thereby reducing the storage one half, the supply will meet the average consumption until 1927.

Because the present excellent quality of Silver Lake water depends upon its long storage, the lake should be kept as full as practicable.

Distributing reservoirs, like the two 4 000 000 gal. reservoirs in Avon, are excellent for meeting sudden fluctuations in consumption. They are too costly for furnishing an auxiliary water supply for several consecutive days. The same result may be accomplished better by an additional pipe line or by using the old source.

The Salisbury Brook Reservoir has a safe yield of 1 500 000 gal. daily, which, if filtered and used, would postpone adding to Silver Lake for four years beyond the time when the consumption would equal the safe yield of the lake, viz., 1931 instead of 1927.

Salisbury Brook Reservoir water, while safe to drink, is unfit for use in a city like Brockton unless it be decolorized. This can be accomplished only by treatment with sulphate of alumina, followed by filtration. The color of the water could be reduced below that of Silver Lake, as proved by the experience of many cities supplied with decolorized water. Filtration through sand without the addi-

tion of chemicals would reduce the average color from 0.52 to 0.31. The water would contain thrice as much color as Silver Lake water, a result which would neither satisfy the consumers nor warrant the cost of filtration.

A new 24-in. pipe line might be laid from Silver Lake, and would serve until 1930, when a third pipe line, 30 in. in diameter, would be required. The present pipe line can deliver 6 000 000 gal., or more than the safe yield of Silver Lake, and it seems illogical to further increase the pipe lines until after additions have to be made to Silver Lake, when one new main, 36 in. in diameter, equal to the probable capacity of the source with future additions, might be laid far more economically.

By using filtered Salisbury Reservoir water to make up deficiencies until additions must be made to Silver Lake, the lake may be kept more nearly full; the construction of new distributing reservoirs may be avoided; an auxiliary supply of 5 000 000 gal. daily for at least a month would be available at all times; the construction of a new pipe line could be postponed until 1927, or longer, if some of the water now going to waste in Avon be filtered and utilized, and the water supplied from the auxiliary source would equal Silver Lake water in color and in safeness.

The estimated construction cost of a 24-in. pipe line is $345 000; of a filter $70 000. The average cost of pumping water from Silver Lake is $13.09 per million gallons; the cost of purifying 1 500 000 gal. daily would be $14.33 per million gallons, or $1.24 per million gallons more. These differences, capitalized at the rates of interest prevailing in Brockton, show in 1927 a difference of $223 374 in favor of the purification plan.

The writer has recommended that the city construct a filter plant at the Brockton Pumping Station, as illustrated by the accompanying sketches, at a cost of $70 000, and postpone the construction of a pipe line until after the average daily consumption equals the average yield of Silver Lake plus the 1 500 000 gal. which may be drawn from the Salisbury Brook Reservoir. The purification plant should have a capacity of 1 500 000 gal. in eight hours, or the equivalent of the dry-weather yield of Salisbury Brook Reservoir, which reservoir should be kept full at all times, that the maximum amount of water may be held in reserve con-

stantly. It is also desirable, in order to maintain the quality of the water, that Silver Lake be kept as full as practicable. This may be accomplished by adding nearby sources in the future.

If the plant recommended be constructed, enough would be saved by the time further large improvements are required to pay a large part of their cost, and the cost of the purification plant as well.

DISCUSSION.

MR. GEORGE A. JOHNSON.* Mr. Weston's paper sets forth certain cardinal reasons why colored waters, like those of Salisbury Brook, are best decolorized by the use of chemicals and filtration through rapid sand filters. He has placed proper emphasis on the fact that while long storage in reservoirs will result in marked color reduction, water thus stored becomes an easy prey to the activities of micro-organisms, which impart to it offensive tastes and odors. Long storage is almost certain to be accompanied by stagnation of the lower strata, and if these layers are drawn upon for the supply, they require aëration before delivery to the consumers.

Mr. Weston also emphasizes the greater cost attending the decolorization of Salisbury Brook water by the use of coagulants and filtration through slow sand filters. This is a feature which has been found true in many other comparisons of like character, and is due chiefly to the necessity for large coagulating and sedimentation facilities, and to the greater cost of construction of slow sand filters of the same daily capacity as rapid sand filters.

FILTRATION FOR THE PHYSICAL IMPROVEMENT OF NEW ENGLAND WATERS.

As a rule, the waters of New England are comparatively free from turbidity, but many of them are quite deeply colored by vegetable stain. To remove these physical defects, filtration has been resorted to in many places. In a few cities, notably Brookline, Lowell, and Reading, Mass., iron removal is an important feature in the purification process.

* Consulting Hydraulic Engineer, New York.

MUNICIPAL WATER PURIFICATION PLANTS IN NEW ENGLAND.

Place.	Kind of Sand Filter.	Year Built.	Rated Daily Capacity, Million Gallons.	Chemicals Used.	Raw Water. (Parts per Million.)		
					Color.	Alkalinity.	Hardness.
Bangor, Me.	Rapid	1912*	8.0	a-b	52	12	28
Belfast, Me.	Rapid	1913*	1.13	a-b	102	10	17
Biddeford, Me.	Rapid	1911*	10.0	a	33	4	20
Gardiner, Me.	Slow	.....	.....	.....	...	..	..
Dover, N. H.	Slow	1909	1.2	None	...	..	..
Exeter, N. H.	Rapid	1906	1.0	a	50	15	30
Franklin, N. H.	Slow	.....	.....	.....	10	..	12
Lebanon, N. H.	Rapid	1907	1.0	a	12	..	16
West Lebanon, N. H.	Rapid	.....	.....	a	26	..	35
Somersworth, N. H.	Slow	1897	1.5	None	65	..	12
Burlington, Vt.	Rapid	1907	2.5	a	15	45	55
St. Johnsbury, Vt.	Slow	1897	2.5	None	...	..	..
Athol, Mass.	Rapid	.....	1.5	a	35	..	11
Brookline, Mass.	Slow	1916	10.0	None	29	40	47
Cheshire, Mass.	.....	1875	.....	None	1	..	22
Cohasset, Mass.	Rapid	1914	0.5	None	44	30	16
Lawrence, Mass.	Slow	1893	6.0	None	25	..	15
Lowell, Mass.	Slow	1915	10.0	None	30	40	28
Marblehead, Mass.	Slow	1908	2.0	None	5	..	10
Middleboro, Mass.	Slow	1913	1.0	None	41	..	27
Milford, Mass.	.....	.....	.....	.....	20	..	29
Reading, Mass.	Rapid	1910	1.5	a-b	25	..	44
Springfield, Mass.	Slow	1909	15.0	a	36	10	14
W. Springfield, Mass.	Slow	.....	1.0	None	12	..	36
Bristol-Warren, R. I.	Rapid	1908	3.0	a-b-c	50	10	27
E. Greenwich, R. I.	Rapid	1907	1.0	a-c	50	7	9
E. Providence, R. I.	Rapid	1893	3.0	a-c	50	12	24
Jamestown, R. I.	Rapid	1910	0.5	a-c	55	9	18
Newport, R. I.	Rapid	1910	3.0	a-c	40	19	29
Greenwich, Conn.	Rapid	1911*	4.5	a	38	15	30
New Haven, Conn.	Slow	1905	12.0	None	20	40	45
Norwich, Conn.	Rapid	1911	1.0	.....	...	..	..
So. Norwalk, Conn.	Slow	1908	3.0	None	15	14	26
Providence, R. I.	Slow	1905	30.0	None	40	9	13

NOTES: a=alum; b=lime; c=soda.
* Newest installations.

In the accompanying table is given a fairly complete list of the municipal water filtration plants in New England. In addition to this list there are quite a number of many sizable rapid filter plants for the purification of waters for industrial use.

These data show that where color removal is aimed at, a coagulant, sulphate of aluminum, is almost always used. Where thoroughly good results in this direction are sought, it is the usual practice in New England, as elsewhere, to employ rapid sand filters, as distinguished from slow sand filters, in conjunction with the coagulating treatment.

Hygienic Efficiency of Rapid Sand Filters.

Aside from the obvious desirability of improving the appearance of public water supplies, by the removal of suspended matters and dissolved color, there is another phase of water purification of far greater importance. This refers to the removal from water of pathogenic bacterial life, particularly the typhoid fever germ.

The public in general senses but dimly the tremendous toll this country pays each year to that plague of filth, typhoid fever. Those of us who have never experienced this disease really think little about it, but the facts are all too plain that each year two hundred thousand people in America suffer from it, and twenty thousand die of it. In the course of a decade, therefore, one in every fifty inhabitants of this country contracts the disease.

Professor Sedgwick describes typhoid fever as a disease of defective civilization, since the widespread and frequent occurrence of this disease is due to defective sanitation; and defective sanitation means defective civilization. Unhappily, this is all too true. Typhoid fever cannot be contracted naturally without taking into the mouth the excrement of another human being, and this is done either by drinking water or milk which has been fouled by human excreta, by eating raw vegetables or other foods which have been contaminated in a similar manner, or by direct hand-to-mouth infection. The result of such practices, followed through ignorance of the possible results, or complacent tolerance by the public of unsanitary modes of living, is a heavy death toll which is entirely preventable, and which needlessly dissipates in vital capital $150 000 000 annually.

Twenty millions of people in the United States are now being furnished with filtered water at a cost not exceeding $8 000 000, or forty cents per capita, per year, and in the cities having filtered water supplies the water-borne typhoid has been practically eliminated, as reliable statistics abundantly show. Filtration of the water supplies of the remainder of the urban population of the United States would cost not more than $11 500 000 per year, and reliable statistics show that to do so would, at the very least, save thirty thousand typhoid cases and three thousand deaths each year, equivalent to vital capital in the total sum of $22 500 000 annually, or twice the money cost of prevention.

REDUCTION IN TYPHOID FEVER DEATH-RATES IN AMERICAN CITIES FOLLOWING THE FILTRATION OF THE PUBLIC WATER SUPPLIES.

(Averages for five years before and five years after filtration.)

City.	Kind of Filter.	Coagulant Used.	Average Typhoid Fever Death-Rate per 100 000 Population.		Per Cent. Reduction in Typhoid Fever Death-Rates which Followed the Filtration of the Public Water Supply.
			Before Filtration.	After Filtration.	
Albany, N. Y.	Slow	Yes	109	28	74
Charleston, S. C.	Rapid	Yes	106	62	41
Cincinnati, O.	Rapid	Yes	56	11	80
Columbus, O.	Rapid	Yes	83	17	78
Harrisburg, Pa.	Rapid	Yes	72	33	54
Hoboken, N. J.	Rapid	Yes	18	13	28
Indianapolis, Ind.	Slow	Yes	46	28	39
Lawrence, Mass.	Slow	No	110	23	79
Louisville, Ky.	Rapid	Yes	57	24	58
New Haven, Conn.	Slow	No	40	25	38
New Orleans, La.	Rapid	Yes	39	26	33
Paterson, N. J.	Rapid	Yes	29	9	69
Philadelphia, Pa.	Slow	Yes	63	20	68
Pittsburgh, Pa.	Slow	No	132	19	85
Providence, R. I.	Slow	No	19	13	31
Reading, Pa.	Slow	No	53	35	34
Scranton, Pa.	Rapid	Yes	25	10	60
Springfield, Mass.	Slow	Yes	22	22	0
Washington, D. C.	Slow	Yes	55	31	43
Wilmington, D. C.	Slow	Yes	35	24	31

The effect of water filtration on the typhoid fever death-rate is well understood, but, again to drive the point home, the speaker presents a tabular statement showing the actual experience in twenty representative cities of this country.

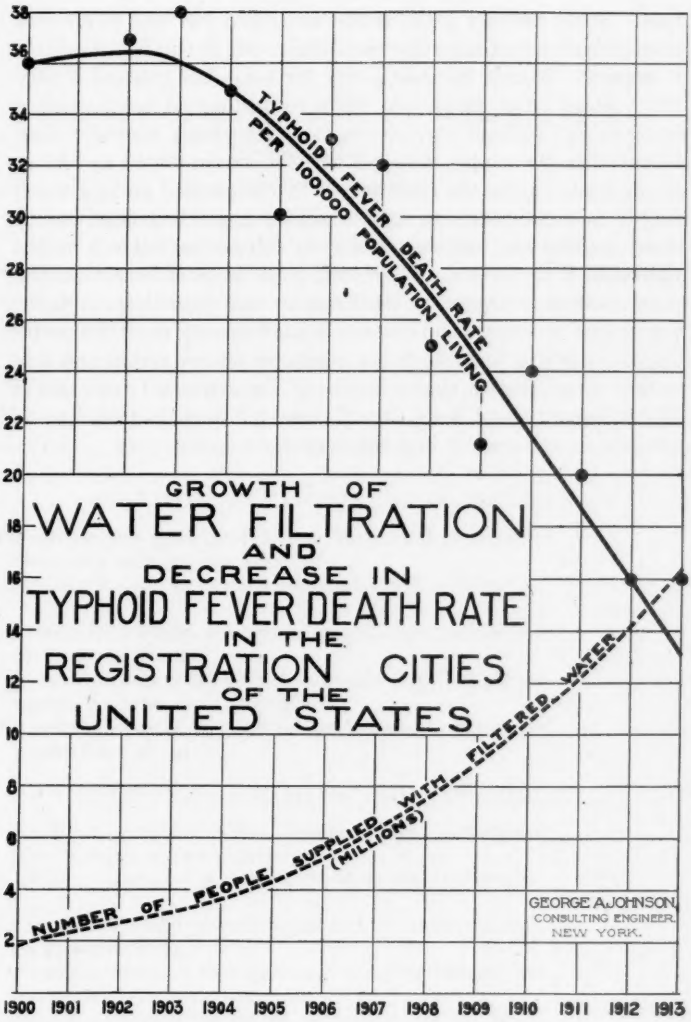
Among sanitarians there appears to be little if any dissension from the view that modern filtration practices actually eliminate the water-borne diseases, or typhoid fever and closely allied disorders at the very least. That is to say, where the plants are properly designed, well constructed, and intelligently operated, water filtration in practical terms is one hundred per cent. efficient.

The speaker next wishes to present some statistics to show how the typhoid fever death-rate, among the urban population of the United States, has decreased as water purification developed. The relationship between the two is strikingly proportional, and holds out every good promise for the future.

RELATIONSHIP BETWEEN THE INCREASE IN POPULATION SUPPLIED WITH FILTERED WATER AND THE DECREASE IN THE TYPHOID FEVER DEATH-RATE IN THE REGISTRATION CITIES OF THE UNITED STATES.

Year.	Population.		Per Cent. which Filtered Water Population was of		Typhoid Fever Death-Rate in Registration Cities.
	Total for Registration Cities.	Total in United States Supplied with Filtered Water.	Total Population of United States.	Total Population Registration Cities.	
1900	21 477 000	1 860 000	2.4	8.7	36
1901	22 146 000	2 400 000	3.1	10.8	34
1902	22 679 000	2 700 000	3.4	11.9	37
1903	23 221 000	3 100 000	3.8	13.3	38
1904	23 724 000	3 800 000	4.6	16.0	35
1905	24 729 000	4 300 000	5.1	17.4	30
1906	26 342 000	5 400 000	6.7	20.5	33
1907	27 145 000	6 300 000	7.2	23.2	32
1908	28 501 000	7 500 000	8.4	23.3	25
1909	29 655 000	8 900 000	9.8	30.1	21
1910	21 342 000	10 805 000	11.7	34.6	24
1911	32 376 000	12 000 000	12.8	37.2	20
1912	33 304 000	14 100 000	14.7	42.4	16
1913	34 230 000	16 500 000	17.0	48.0	16

Where a city takes its public water supply from surface streams and lakes, it is always liable to dangerous contamination at any


GROWTH OF
WATER FILTRATION
AND
DECREASE IN
TYPHOID FEVER DEATH RATE
IN THE
REGISTRATION CITIES
OF THE
UNITED STATES
TYPHOID FEVER DEATH RATE PER 100,000 POPULATION LIVING
NUMBER OF PEOPLE SUPPLIED WITH FILTERED WATER (MILLIONS)
GEORGE A. JOHNSON,
CONSULTING ENGINEER,
NEW YORK.
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913

time. Strict sanitary patrol of the watershed will tend to prevent gross pollution and minimize the danger, but it will not eliminate it entirely. Merely because a city for years has enjoyed a very low typhoid fever death-rate while continuing to use a surface water supply without purification, is no reasonable assurance that at any time the supply may not become contaminated and cause an epidemic among the consumers. No unpurified surface water supply is entirely safe to drink, and on hygienic grounds alone water purification will always show a substantial balance on the right side of the ledger. Where one dollar is spent for pure water, many dollars are saved in the form of vital capital through the prevention of sickness and death. If a community of 19 000 people spends each year forty cents per capita for filtered water, and thus each year prevents a single death and the attendant ten cases of illness from typhoid fever, it will come out even financially, and increase its self-respect into the bargain.

REPORT OF COMMITTEE ON METER RATES.

[*Presented February 9, 1916.*]

(Subject to Revision.)

To the New England Water Works Association:

Your Committee on Meter Rates, having presented a preliminary report in September, 1914,* and having had the benefit of such discussion as has taken place by members of the Association, now presents its final report.

Your Committee has prepared a standard form for Meter Rates. This is given in alternate forms, according as gallons or cubic feet are used, and as the unit of time is annual, quarterly, or monthly. The schedules are as follows:

QUANTITIES IN GALLONS. BILLS ANNUALLY.

For each service supplied by ¾-in. meter there shall be a charge for the service and meter per annum, of $.....

In addition thereto, for all water drawn there shall be charged: Per 1 000 gal.

For the first 300 000 gal. of water per annum, or any part thereof, the Domestic Rate of $.....

For water in excess of 300 000 gal. and under 3 000 000 gal. per annum, the Intermediate Rate of $.....

For water in excess of 3 000 000 gal. per annum, the Manufacturing Rate of $.....

QUANTITIES IN GALLONS. BILLS QUARTERLY.

For each service supplied by ¾-in. meter there shall be a charge for the service and meter per quarter, of $.....

In addition thereto, for all water drawn there shall be charged: Per 1 000 gal.

For the first 75 000 gal. of water per quarter, or any part thereof, the Domestic Rate of $..... ...

For water in excess of 75 000 gal. and under 750 000 gal. per quarter, the Intermediate Rate of $.....

For water in excess of 750 000 gal. per quarter, the Manufacturing Rate of $.....

* Journal N. E. W. W. A., Vol. 28, 199 (1914).

QUANTITIES IN GALLONS. BILLS MONTHLY.

For each service supplied by ⅝-in. meter there shall be a charge for the service and meter per month, of $.....

In addition thereto, for all water drawn there shall be charged: Per 1 000 gal.

For the first 25 000 gal. of water per month or any part thereof, the DOMESTIC RATE of $.....

For water in excess of 25 000 gal. and under 250 000 gal. per month, the INTERMEDIATE RATE of $.....

For water in excess of 250,000 gal. per month, the MANUFACTURING RATE of $.....

QUANTITIES IN CUBIC FEET. BILLS QUARTERLY.

For each service supplied by ⅝-in. meter there shall be a charge for the service and meter per quarter, of $.....

In addition thereto, for all water drawn there shall be charged: Per 100 cu. ft.

For the first 10 000 cu. ft. of water per quarter or any part thereof, thereof, the DOMESTIC RATE of $.....

For water in excess of 10 000 cu. ft. and under 100 000 cu. ft. per quarter, the INTERMEDIATE RATE of $.....

For water in excess of 100 000 cu. ft. per quarter, the MANUFACTURING RATE of $.....

QUANTITIES IN CUBIC FEET. BILLS MONTHLY.

For each service supplied by ⅝-in. meter there shall be a charge for the service and meter per month, of $.....

In addition thereto, for all water drawn there shall be charged: Per 100 cu. ft.

For the first 3 300 cu. ft. of water per month, or any part thereof, the DOMESTIC RATE of $.....

For water in excess of 3 300 cu. ft. and under 33 000 cu. ft. per month, the INTERMEDIATE RATE of $.....

For water in excess of 33 000 cu. ft. per month, the MANUFACTURING RATE of $.....

The prices to be written in the schedule should be fixed in each case by the local authorities to meet local conditions and to produce the required revenue, and the committee makes no suggestion as to how great they should be. It suggests, however, that the methods of determining the service charge and the rates for each class of water should follow those outlined in its preliminary report.

For a domestic service with $\frac{5}{8}$-in. meter, the ordinary service charge may properly be about $3 per annum where service and meter are paid for by the taker; $4 where the meter is furnished by the works, and $5 or $6 where both meter and service pipe are paid for by the works, the lower figure being used where the average cost of the service pipe is under $15, and the higher where it is greater than $15. The above charges, however, are subject to modification, depending upon local conditions, and in general the method of fixing them should be that laid down in the preliminary report of this committee.

It is recommended that the price per 1 000 gal. or per 100 cu. ft. be in most cases an even number of cents, omitting fractions, and that the domestic rate and manufacturing rate be first fixed; that the manufacturing rate should very seldom be less than half of the domestic rate, and that for the intermediate rate the price be to the nearest cent midway between the average and the mean proportional of the domestic rate and the manufacturing rate. In other words, it will ordinarily be half-way between the two, or half-way between the two less one-half cent.

The minimum charges for services with meters larger than $\frac{5}{8}$-in. may be fixed at larger sums, to be computed by the methods indicated in the preliminary report.

A flat rate for all quantities may be made by fixing the same price for water for domestic purposes and for manufacturing purposes, and in this event the whole schedule may be simplified.

The committee further recommends that where the same works supply water in different services under conditions which impose substantially greater relative expense in one or more such services as compared with others, by reason of high-service pumping or otherwise, that it is just and equitable that discriminations be made and that for water sold in such districts the additional cost may be approximately ascertained and an added price may be charged for water sold in such districts.

For example, to one of the schedules as drawn above might be added the words:

"For all water sold in the high-service district the charges shall be.....cents per 1 000 gal. (or per 100 cu. ft.) greater than those in the above schedule."

The committee recommends that statistics of sales of water by meter be classified on the basis that is used in the preparation of the rates schedule, and suggests that this can be done for any water-works system, even though the meter rates are not in the form recommended. The classification might appropriately be in this form:

STATISTICS OF.....WATER WORKS FOR YEAR.....

	Services coming entirely under DOMESTIC RATES, that is, averaging less than 820 gal. per day.	Services coming under INTERMEDIATE RATES, that is, averaging between 820 to 8 200 gal. per day.	Services securing MANUFACTURING RATES, that is, using an average of more than 8 200 gal. per day.	Total.
Number of services.....				
Total amount of water supplied to these services. Millions of gallons.....				
Total amount of revenue derived from these services. Dollars.....				

The above constitutes all the underlying data that are necessary. From them the amount of water that would be sold under each of the rates, if a rate in the form now recommended were adopted, can be readily ascertained, and also the present revenue derived therefrom. From these the average present receipts from water quantities sold within these limits can be determined. With this information, the rates in the form recommended by your committee that would produce the same amount of revenue as present rates, in any case, can be ascertained.

Compiling statistics in this form will further permit comparison of meter rates now in use under schedules which do not permit direct comparisons to be readily made, and will facilitate such comparisons on an accurate and uniform basis.

The committee calls attention to the chart prepared by it, and to be obtained in quantities from the Secretary, as a convenient means for plotting and comparing various meter rates.

The committee recommends that the form for rates now presented be adopted by the Association as a standard.

The committee further reports that the other matters referred to it, relating to the study of waste of water, are still under consideration. As these matters are not in any way related to those first referred to the committee, the committee now reports on its primary work, which is complete, and asks for further time in reporting upon the other matters.

ALLEN HAZEN, *Chairman*,
A. W. CUDDEBACK,
A. E. BLACKMER,
JAMES L. TIGHE,
CHARLES R. BETTES,
PHILANDER BETTS,
Committee on Meter Rates.

DISCUSSION.

MR. C. W. SHERMAN.* I move that this report be accepted, and that the committee's recommendation as to the adoption of the form for making out meter rates be adopted as the standard of the Association.

(The motion is seconded by Mr. C. M. Saville.)

MR. G. A. KING.† Mr. President, would it not be well for the Association to know what those recommendations are a little more than we can know now? Should they not be printed and sent to the members and then action taken on them?

MR. SHERMAN. It seems to me, Mr. President, that the Association would not commit itself to anything that might in any way work out unfortunately in adopting this as a standard, and until something is adopted as a standard there is not much likelihood of getting it used. If, after a year or two, there is any possibility of improving it, it would not be a difficult matter to amend

* Of Metcalf & Eddy, Boston.
† Superintendent Water Works, Taunton, Mass.

it. The prime thing, as I see it, is a method of arranging these things as a standard method. The committee does not in any way recommend the prices that should be put in; that should be fixed by each place independently.

MR. FRANK L. FULLER.* I agree with Mr. King that we ought to have a chance to study these rates before we vote to adopt them. I think that at a subsequent meeting the motion would be in order.

MR. MAURICE R. SCHARFF.† In addition to the desirability of giving further study to this schedule, and possibly the reading of this committee report, it seems to me there are at least one or two rather important criticisms that may be made of the schedule as presented that ought to be given consideration, careful consideration, before this Association commits itself to this form of schedule. I will refer to those as briefly as I can.

The general form of the schedule I believe is very excellent indeed, and I, for one, am pleased to see a schedule recommended in the form of a service charge without any allowance of water, and a sliding scale meter rate. But the service charge recommended, amounting to from three to six dollars per annum, is evidently based wholly upon the assumption that the consumer is to pay the fixed charges upon the cost of the meter and service connection only. Now, it seems to me that the idea of a rate schedule is, in the first place, to distribute the cost of maintaining a water-works plant among consumers somewhat in proportion as they contribute to that cost, and the idea of making a division between a service charge and a meter charge is primarily to assess by meter charge those costs which depend more or less directly upon the amount of water consumed, and to assess by a service charge those costs which are wholly independent of the amount of water consumed. Now, it is obvious that in addition to the fixed charges upon the meter and connection, the fixed charges upon a very large portion of the water-works plant, including the entire distribution system and considerable portions of the supply works, are wholly independent of the amount of water consumed by the connected consumers and dependent wholly upon the

* Civil Engineer, Boston.
† Pittsburgh, Pa.

demands thrown upon the system by those consumers. I believe, therefore, that a service charge which contains no allowance for water consumed but which is sufficiently large so that the consumer shall pay his fair proportion of all of the charges which he occasions to the water works by his connection, and which will include the fixed charges upon the plant for supplying the water and distributing it to him, would be fairer and better adapted to practical use in the long run than such a small service charge as is here suggested.

Another disadvantage of the small service charge here suggested is that all of these additional fixed charges to which I have referred are transferred into the meter rate, which is thereby made so much higher. The direct result of this is to penalize the long-hour high-load factor consumer, who uses water perhaps twenty-four hours per day at a more or less uniform rate, the most desirable type of consumer, and the one to whom the water works can best afford to make concession in order to retain; and by raising the meter rate and holding down the service charge, to reward the low-load factor short-hour consumer, who is the most expensive consumer to supply.

One other criticism of the schedule that may be made is that it seems to me it is entirely too definite with respect to suggesting the rates of consumption which shall be adopted as the dividing lines between the several steps of the sliding scale. To my mind, the justification of a sliding scale of meter rates is the fact that a water-works plant, although it may have the monopoly of the supply of water in a given territory, is nevertheless placed in competition with other possible sources of supply whenever it comes to supply a consumer large enough so that a separate supply system becomes an economic possibility. And the justification for the sliding scale of rates is the necessity of making concessions to such large consumers so that they may obtain water at something approaching the price at which they might obtain it if they put in independent supplies of their own. In other words, we have here exactly the same problem of rate making that the electric light and power companies have to face in going into the market and attempting to displace isolated power plants. That being the case, the so-called manufacturing rate or lower step of the

sliding scale schedule should depend, I think, entirely upon the local conditions with respect to the availability of other sources of supply and the number and character of large consumers who have to be considered as possibly going to other competitive sources of supply.

For those reasons it seems to me entirely impractical to fix in any standard form either the rates of consumption which should be considered as the proper dividing lines between the several steps of the schedule or the ratio between the maximum and minimum rates of the schedule, as is suggested in this report. And not only do I think it wise that further consideration should be given to the report before it is adopted, but it appears to me very unwise that it should be adopted unless some changes along these two lines should first be made.

MR. SHERMAN. I am hardly in a position to be arguing for the committee, not being a member of it and not having seen the report before I read it. But I think Mr. Scharff's first criticism is made under some misapprehension of what the report says. While they do suggest that the method of fixing the service charge might very properly follow the method outlined in their preliminary report, and be based, as Mr. Scharff says, on the fixed charges on service pipe or meter, they do not at all specify it in the standard form of rates, and the Association by accepting the suggested form as a standard would not accept that method of fixing the service charge. That would be left to be fixed by each water department for itself. The specific wording here is, "It suggests, however, that the method of determining the service charge and the rates for each class of water should follow those outlined in its preliminary report." That does not, however, make them a part of the standard method of rating.

The other point raised by Mr. Scharff, that of the points of division between domestic, intermediate, and manufacturing rates, is, of course, fixed in their recommendation, and must be fixed if anything is to be taken as a standard. It does not seem to me that that is necessarily an argument against it. The committee, at least in its preliminary report, recognized fully that local conditions might in some cases make any such standard as they recommend impractical. And unquestionably where local

conditions call for something different than would conform to the standards, the local conditions should govern. But there are a great many cases where there is no particular reason where any convenient point should not be considered the dividing line, and for all such cases it would seem desirable that such a standard be adopted. Certainly we can make no comparison of quantities of water used under the different charges, or of what the changes in revenue would be for certain changes in charges, unless we have some definite division point for what may be considered standard rates.

Under these circumstances, and bearing in mind that the committee does not recommend as part of its standard what the service charge should be, but merely suggests a method which seems to them a reasonable way of getting at it, and that while this matter of dividing the different classes of charges may not be applicable in all cases, it still probably is in a large percentage of them, and if anything is to be standard it has got to be adopted by somebody, and I think our committee is as well qualified to judge what those points are as any committee could be, — I think there is no reason yet advanced why the Association should not adopt this.

Mr. Martin.* I think there is one reason why we should postpone this matter to the next meeting, and that is the lack of members present. The members have drifted out. There are perhaps not more than half as many here as there would be if we take it up at the beginning of the next meeting. It seems to me that it would be a good scheme to have this report printed and forwarded to the members with the notice of the next meeting, and then have it taken up with a full membership and discussed, if it is necessary to discuss it, and, if not, have it voted on when there are enough here to know just what is going on. I offer that suggestion.

Mr. King. Mr. President, I move that as a substitute motion to Mr. Sherman's, that it be printed and sent to members and action taken at the next meeting.

Mr. Sherman. That is entirely acceptable, Mr. President.

President Sullivan. Then it is made as a motion, as stated by Mr. Martin, that it be printed and sent to members and be

* Superintendent of Water Works, Springfield, Mass.

discussed at the beginning of the next meeting. The other motion is withdrawn, if there is no objection. Is there anything to be said on that motion?

(The motion is adopted.)

Discussion at Meeting of February, 1916.

Mr. Allen Hazen * (*by letter*). The application of the methods proposed by the committee to the rates of a specific system may be helpful. It is proposed to find a new rate conforming to the committee's recommendation that will produce the same revenue that is produced by present rates.

The plant selected for this study is a small one, with 4 958 meters and a few unmetered services which are not brought into this study. Waste has been persistently hunted for years, and the per capita consumption is unusually low.

On Fig. 1 a solid line shows the present rates. On the same sheet are drawn three other solid lines, which together show the annual bills up to $5 000 per annum for all quantities of water drawn. These total-bill lines are easily drawn on the meter-rate sheet of the committee, and add considerably to the convenience of the study.

The meter rates for this plant, from a scientific standpoint, are bad. They advance by irregular steps. It is sometimes possible to get a lower bill by drawing more water. The rates for the largest consumers are too low, and for certain intermediate ones they are too high. The schedule, however, is fixed by contract, has successfully withstood attacks, and is a good revenue producer. It is certain that it will not soon be changed, but we may, nevertheless, see what could be done to improve it if conditions permitted.

An analysis of the records for the last year shows that 4 839 of the services drew less than 300 000 gal. each. On the proposed classification all water drawn by them would come under the Domestic Rate. These services drew in the aggregate 150 000 000 gal. of water, an average of 85 gal. per day for each service. Among the larger services there were 99 drawing larger quantities

* Civil Engineer, New York.

but less than 3 000 000 gal. each, and therefore coming under the Intermediate Rate. These drew, in all, 47.7 million gallons, an

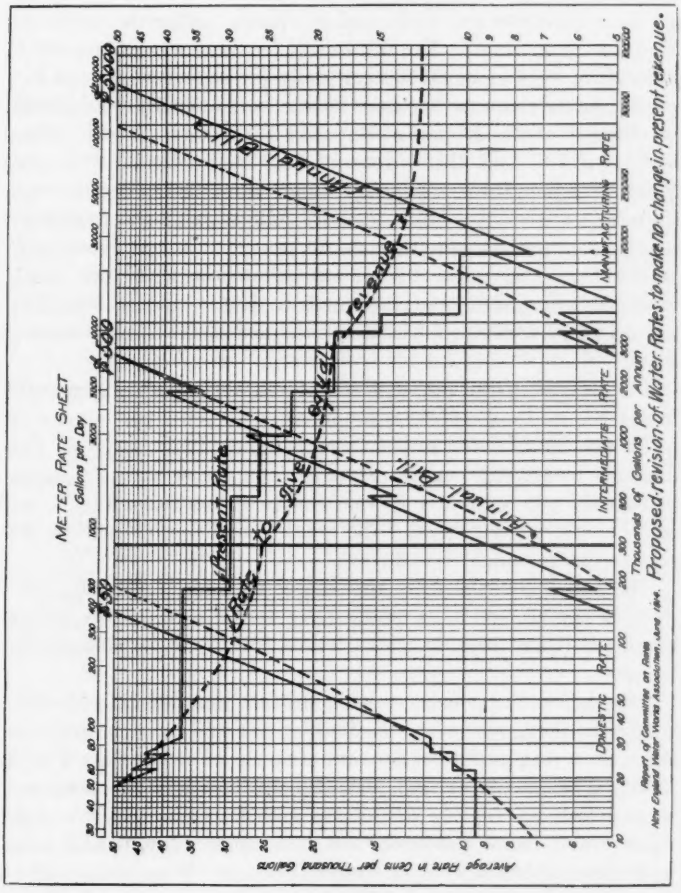

METER RATE SHEET
Gallons per Day
Average Rate in Cents per Thousand Gallons
DOMESTIC RATE
INTERMEDIATE RATE
MANUFACTURING RATE
Thousands of Gallons per Annum
Present Rate
Proposed revision of Water Rates to make no change in present revenue.
Report of Committee on Rates
New England Water Works Association, June 1914.

FIG. 1.

average of 1 320 gal. per day for each service. Of this amount, 300 000 gal. from each service during the year, or 29.7 million

gallons, would be charged at the Domestic Rate. The remaining 18 000 000 gal. drawn by these 99 services would be charged at the Intermediate Rate. There were, further, 20 services drawing over 3 000 000 gal. each, and so coming under the proposed Manufacturing Rate. The total draft by these was 143.3 million gallons, an average of 20 000 gal. daily for each service. Of the whole quantity drawn by these 20 services, 6 000 000 gal. would be charged at the Domestic Rate, 54 000 000 gal. at the Intermediate Rate, and the remaining 83.3 million gallons at the Manufacturing Rate. Bringing these quantities together for the whole system, it is found that 341 million gallons were sold, of which 185.7 million gallons, or 54.45 per cent., would be charged at the Domestic Rate; 72 million gallons, or 21.12 per cent., would be charged at the Intermediate Rate; and 83.3 million gallons, or 24.43 per cent., would be charged at the Manufacturing Rate.

The service charge for local conditions, computed as suggested in the committee's report, is found to be 40 cents per month, or $4.80 per annum, for a $\frac{5}{8}$-in. service. For 4 958 services, this amounts to $23 800. About 3 per cent. of the services are larger and would pay a greater service charge. Approximately, 5 per cent. would be added, and the total amount produced by the service charge would be $25 000.

The actual revenue from the sale of water was $91 226. Deducting the amount that would have been raised by the service charge, if it had been in effect, leaves $66 226 to be charged for water.

The slide in the present scale exceeds the 2 to 1 ratio which the committee suggests as the ordinary maximum. In finding new rates, it is proposed to reduce the amount of slide to the 2 to 1 limit. The calculation will be made by first applying assumed rates which are in this proportion and determining what these rates would have produced and how much they would have to be increased to produce the desired revenue. It makes no difference what rates are assumed for the first calculation, so long as they are in the right proportion; 20, 14.6, and 10 cents per 1 000 gal. will be used. At these rates the revenue that would have been derived is as follows:

185.7 million gallons @ 20¢	$37 140
72 million gallons @ 14.6¢	10 510
83.3 million gallons @ 10¢	8 330
Total	$55 980

The required sales to equal present revenue as found above is $66 226, or 18.3 per cent. more than the amount found by this trial. The assumed rates must, therefore, be raised by 18.3 per cent. So corrected, they are found to be 11.83, 17.27, and 23.66 cents per 1 000 gal. As cubic feet are used, the corresponding values are found to be 8.87, 12.95, and 17.75 cents per 100 cu. ft. The round figures 9, 13, and 18 are sufficiently close and may be used.

As the bills are rendered monthly, the quantity figures in the committee's schedule are divided by 12 (months in a year) and by 7.5 (gallons in a cubic foot), and the schedule with the blanks filled in is as follows:

For each service supplied by ¾-in. meter there shall be a charge for the service and meter per month of	40¢
In addition thereto, for all water drawn there shall be charged:	Per 100 cu. ft.
For the first 3 300 cu. ft. of water per month, or any part thereof, the Domestic Rate of	18¢
For water in excess of 3 300 cu. ft. and under 33 000 cu. ft. per month, the Intermediate Rate of	13¢
For water in excess of 33 000 cu. ft. per month, the Manufacturing Rate of	9¢

On Fig. 1 the rates corresponding to this schedule are plotted as a dotted line. The annual bills are also shown. These dotted lines show a schedule of rates that conforms to the committee's recommendation in all respects and that would have produced the same revenue for this plant as the present rates shown by solid lines actually did produce for the record year.

This plotting shows clearly just which classes of consumers would have their rates raised and which would have their rates lowered. It is interesting to note that consumers drawing from 50 to 150 gal. per day on an average, these, being two thirds of the whole number, would not be greatly affected by the change.

There is a further comparison that may be made and that has some interest in this case. On page 212 * of the printed report is given a representative rate in the form proposed by the committee that in a general way is found to correspond approximately with current practice of American cities that have adopted the meter system. If this schedule had been in effect at the plant in question during the past year, the charges under it would have been as follows:

Service charge for 4 958 services @ $4.20 (=$3.00+$1.20) . . .	$20 700
Add approximately for larger services 5%	1 000
185.7 million gallons of water @ 21¢	39 100
72 million gallons of water @ 16¢	11 500
83.3 million gallons of water @ 11¢	9 200
Total revenue at this rate	81 700

The actual revenue from the sale of water was $91 226, which is 11.7 per cent. more than the sum that would have been received by the above-mentioned rates. It is thus ascertained that the actual rates of this company produced a revenue that is about 12 per cent. greater than the average or representative rate as above defined would have done.

The writer fully concurs in a great deal of what Mr. Scharff says in regard to the service charge, but he thinks that there is one substantial element in the situation which has been overlooked by Mr. Scharff, and which makes it undesirable and impracticable to greatly increase the service charge.

In a normal, completely metered water-works system, 90 per cent., more or less, of all the takers are served by $\frac{5}{8}$-in. meters and services. The smallest cottages and houses of considerable size are supplied through pipes of the same size. A service of this size is practically large enough to take care of most of the takers, and there are practical reasons why it would not be wise to increase the size of the service pipe unnecessarily. On the other hand, practical considerations do not warrant reducing the size of the pipe to the smallest houses.

If the whole amount that might, in the aggregate, be assessed in service charges against all the houses could be equitably assessed on the several houses in proportion to the facilities for the use

* JOURNAL N. E. W. W. A., Vol. 28 (1914).

of water in them, there would be considerable merit in the procedure of assessing the full amount in that way. The small cottage would then pay a small service charge, and a good-sized house would pay a much larger service charge, even though the size of the pipe and meter were the same.

Practically it would be very difficult to apply such a system of grading service charges, and it was not seriously considered by the committee.

To divide the whole amount that might be placed on service charges by the number of services, and to distribute it equally, is doing a substantial injustice to the smallest takers, and lets the larger houses off at less than their fair share of cost.

The way that the matter is practically carried out at the present time in a majority of American cities is to assess the extra cost that might be attributed to service charge by theoretical segregation in the form of an additional price per thousand gallons on certain quantities of water that are first drawn from each service. This gives rise to the sliding scale. This procedure distributes the said charges, or so much of them as are represented by the higher rates, among the different consumers in proportion to the quantities of water that are drawn. The procedure probably does not put all the extra charges exactly where they should best go, but in a broad, general way the writer believes that it distributes them approximately in an equitable manner, and that the general procedure outlined by the Committee's report will result in a more equitable distribution of all the burden among the takers than would result from the use of a much higher service charge, and the elimination of all, or a part of the excess charge on the first quantities of water drawn.

The writer believes that the present average practice of American water works is pretty nearly right in regard to this matter, and the Committee's work accepts this, but proposes to standardize it; and the adoption of the Committee's reports will tend to line up rates and to eliminate many erratic rates now in force.

The writer also notes the suggestion that the points at which change in rates should take place should be differently selected for different communities. No doubt there would be here and there local conditions that might tend to modify somewhat the points that

might be selected if local data only were considered. This would relate mainly to special rates for very large quantities, in making which some flexibility in procedure may be desirable. And such flexibility is not inconsistent with the procedure proposed by the committee for all smaller services. On the other hand, generally speaking, the conditions of service in American cities are tolerably uniform, and the writer believes that it is for the good of the service that the points for change in rates should be standardized. This will permit direct comparison between different systems, and will give stability and definiteness to the business that is now sadly lacking.

PHILANDER BETTS, Ph.D.* (*by letter*). In making this addition to the discussion of this subject, I do not wish to be understood as taking issue with any of the other members of the committee. My feeling is that the report of the committee is practically the resultant work of the committee as a whole, but I wish to call attention to a somewhat different method of treating this subject which was originally set out by Hopkinson in England, and by Henry L. Doherty in this country treating of rates for electricity supply.

FORM OF RATE SCHEDULES.

There is an increasing realization on the part of the management of public utilities that all schedules of rates should be so designed as to properly distribute the costs upon those who benefit by them. Any failure to do so is, to a greater or less extent, an unjustifiable discrimination.

Any system of rates which results in relieving any considerable proportion of customers from their just burdens only serves to load on others a burden which they should not be asked to bear.

The cost of central station service can be generally divided into three classes:

(1) Those elements of cost which are strictly proportional to the number of customers, such as billing, meter reading, accounting, collecting, meter testing, etc.

(2) Those elements of cost which are proportionate to the maximum demand which a customer may make upon the plant and system of the public utility.

* Fellow, American Institute of Electrical Engineers; Member, American Society of Mechanical Engineers.

(3) Those elements of cost which are in proportion to the actual amount of water, gas, or electricity actually used.

Any system of rates which omits from proper consideration any great proportion of the costs referred to above results in an overcharge to some and too great liberality to others.

In the following Table 1, an attempt has been made to allocate all of the expenses for a given year to the appropriate class of

TABLE 1.

EXPENSES IN CONNECTION WITH SERVICE TO

Item.	$300 000.			$60 000.		
	Private Customers.			Fire Protection.		
	Class 1.	Class 2.	Class 3.	Class 1.	Class 2.	Class 3.
Profit, 7 per cent		$21 000.00			$4 200.00	
Taxes — ⅞ plus ¼		2 370.00			395.00	
Administration	$1 000.00	722.42		$8.45		
Interest temporary loans			$435.70			
Insurance		403.04			67.17	
Stationery and stamps	361.88					
Telephones	113.29		100.00			
Other office expenses	69.43					
Wages, clerks, etc.	1 305.50					
Wages, outside	450.17	100.00	200.00		100.00	
Legal expenses	100.00	105.00				
Tools			90.11			
Automobile maintenance	397.67	100.00	400.00			
Painting and repairing standpipe		871.23			145.20	
Painting and repairing hydrants					128.93	
Painting and repairing meters	240.78					
Painting and repairing buildings		178.42				
Painting and repairing pipe lines		60.79	600.00			$100.00
Miscellaneous expenses	195.79	200.00	250.00		50.00	
Depreciation		4 139.65			700.00	
Pumping:						
Wages			912.97			
Fuel			2 526.30			
Oil, waste, packing			145.71			
Lighting stations			62.11			
Repairing machinery			181.68			
Miscellaneous expenses			133.46			
	$4 234.51	$30 250.55	$6 038.04	$8.45	$5 786.30	$100.00
		$40 523.10			$5 894.75	

Per customer	$2.22	Per hydrant:	
Per demand unit	12.06	214) 5 894.75	
Per gal. pumped	7.2c		$27.54
Total customers	1 905		
Total gal. pumped	84 000 000		
Total demand units	2 507		

costs. These figures are taken from the actual operating expenses of one of the New Jersey seashore companies.

It will be noted that depreciation and interest are all put in the second class of costs. The reason for this is that at the present time rates of return and rates for depreciation are based upon the investment, and do not take into account the efficiency in operation. It may be, in the last analysis, that we ought to base part of our profit on the amount of the investment and part of it on the efficiency in management. This would throw a portion of our profit into the third class of expenses.

In the analysis referred to, it will be noted that the expenses have been divided into two general classes, — those referring to fire protection and those referring to the cost of furnishing the service to private consumers. The method of division of the investment for this purpose is not up for discussion at this time, and I will not refer to my reasons for dividing the investment in the way I have. It will be noted at the head of this table that I have allotted an investment of $60 000 to the fire protection, and an investment of $300 000 to private consumers.

In the table it will be noted that the amount charged in connection with fire protection is $5 894.75. As there were in use 214 hydrants, the unit cost per hydrant was $27.54. The contract price paid by the municipality was $25 per hydrant. The relation between these figures shows that the municipality should pay at a somewhat greater rate for hydrant service under the present conditions. Their failure to do so throws some of these costs on consumers generally.

With reference to private customers, at the time under discussion, there were approximately 1 905 customers carried on the books of the company. Table 1 shows that the Class 1 expenses amounted to $4 234.51. This gives as the unit cost per customer for Class 1 expenses, $2.22. With reference to the division of Class 2 expenses over the various classes of customers, some consideration must be given to the methods for determining the maximum demand made by each customer.

In deciding upon the method to be adopted in measuring the demand which each customer may make upon the plant of a water company, we meet with considerable difficulty. In the earlier

days, water was supplied at flat rates, these rates being based upon an assumed demand, although demand and consumption were in general considered to be the same thing by the companies.

Demand indicates the draft or requirement a customer *can* make momentarily; *consumption* indicates the actual amount he does draw in the course of time. Flat rates for water supply were made up by adding together charges of an arbitrary amount for each one of various kinds of fixtures, each additional fixture carrying with it an additional charge. In some cases, water rates have been computed in proportion to the width of the lot occupied by the building supplied. This, however, has mainly been true in connection with municipally operated supplies. Charges have also been computed by the square feet of floor area in a building; they have also been computed by making allowances of a certain amount for each sleeping room, this being an assumption that the number of sleeping rooms was a measure of the number of occupants in a building, and in turn the number of occupants was the best measure of the use of water.

In recent years, flat rates have been based upon the number and character of the fixtures. It will readily be seen that the methods of charging referred to would lead to great inconsistencies, due to the fact that some persons will use a very much greater quantity of water than others occupying premises equipped in exactly the same way. These inconsistencies have led to complaints, and the final result has been the adoption of meters in a great many of our communities. In some places, meters are used in connection with every customer; in others, meters are only used where the conditions are peculiar and where flat rates lead to great inequality in the treatment of its customers.

It has been stated above that costs for service may be generally divided into three classes, and with such a division no one will disagree, although there may not be entire agreement as to the method of classifying the various kinds of expenses. This being true, it will be equally obvious that any system of rates based upon a uniform charge per unit of product, without any other element in the rate schedule, or without a minimum charge, to say the least, could not help but relieve some customers of charges which they should properly bear.

The problem before us is to ascertain how we may determine the demand that may be made by each customer upon the plant and distribution system of the water company. The size of the meter and the size of the service pipe, if correctly proportioned to the fixtures installed in a building, appear to be the best index for determining the demand. Such methods are common in connection with electric light schedules, but with water supply the conditions are somewhat different from those of electric light plants.

With electric-lighting service, there are available maximum demand meters, which measure, as the name implies, the maximum demand made by the customer, that is, the maximum demand for current at any one time.

With regard to water supply, there is no such instrument available as a meter registering the maximum demand at any particular time, and even if it were available, it might not be a true index of the proper demand charge to be made against a given customer, due to the fact that the water user can usually wait a few moments if the demand for water is too great either in his own building or in the immediate vicinity. Further, water can be stored in tanks in buildings, and can be supplied with some degree of uniformity to the fixtures in the buildings. Such methods are common in our large cities, where, due to the height of the buildings, it is necessary to install pumps with tanks located on the roof or in the upper portions of the buildings. In such cases, a comparatively small pump takes water from the street mains, and, operating continuously, or nearly so, feeds the tank on the roof. The fluctuations in demand by the occupants of the building are supplied from the tank. Under such conditions, the maximum demand made by a given building may be, and usually will be, smaller than where no pumping system, with its accompanying tanks, is found.

Another difficulty in using the size of meter or size of service pipe as a positive measure of the demand which a customer will make, is due to the fact that the variation in capacity in meters is so great. The smallest meter ordinarily in use is the so-called ½-in. meter, and is used in connection with ½-in. service pipe; the next larger size is the ¾-in. meter, used in connection with the

¾-in. service pipe. The ¾-in. meter has just twice the capacity of the ½-in. meter. The 1-in. meter has four times the capacity of the ½-in. meter; the 1½-in. meter, six times; the 2-in. meter, ten times; the 3-in. meter, eighteen times; the 4-in. meter, thirty-six times; and the 6-in. meter, sixty times the capacity of the ½-in. meter. Where the larger meters are required, the discrepancy, it will be noted, is not so great, but the difference between the capacity of the ½-in. meter and the ¾-in. meter is so great proportionately as to tend toward injustice if the capacity of these smaller meters is taken as a direct and definite measurement of the demand. For the purposes, however, of this discussion, and in order to obtain a basis for calculating the demand, I have adopted the term "demand unit," using the rated capacity of a ½-in. meter as one demand unit. The rated capacity in demand units of each size of meter is shown by the following Table 2.

TABLE 2.

COMPUTATION OF "DEMAND UNIT."

Size of meter, inches .	½	¾	1	1½	2	3	4	6
Rated capacity . . .	15	30	60	90	150	270	540	900
* Ratio of capacity . .	1	2	4	6	10	18	36	60

In 1911 there were approximately 1 905 meters, and, based on the above method of calculating the demand, the following Table 3 has been arranged to show the total number of "demand units" as measured by the number of meters then in use by the company.

TABLE 3.

Size.	Number.	Demand Unit.	Total Demand Unit.
½	1 617	1	1 617
¾	209	2	418
1	48	4	192
1½	20	6	120
2	10	10	100
3	0	18	0
4	0	36	0
6	1	60	60
	1 905		2 507

* Using rated capacity of ½-in. meter as the "unit of demand," the "demand unit" value for each size of meter is shown in line.

If the computations in Table 1 are on a correct basis, each customer found on the books of the company should pay $2.22 per annum. Each customer with a ½-in. meter should pay $12.06; each customer with a ¾-in. meter will pay $24.12, and the amount which each customer will pay for the second class of expenses will be as shown in Table 4, the amount paid to be determined by the size of the meter used in measuring the water supplied.

TABLE 4.

Size of Meter. Inches.	Amount to be Paid.
½	$12.06
¾	24.12
1	48.24
1½	72.36
2	120.60
3	217.08
4	434.16
6	723.60

For the two payments already made, the customer would receive no water. These first two charges are to cover (1) costs of billing, meter reading, accounting, etc.; (2) maintenance costs, including interest and depreciation upon the quota of plant and mains installed and kept at all times in readiness to supply the respective water-takers. A study of Table 1 will make this clear. Water used, that is, the pumping cost of water used, would be charged for in addition, at the rate of 7.2c per thousand gallons. Such a method of charging would probably result in a more equitable distribution of the costs over the customers who cause them.

Systems of rates, however, made up on this plan are frequently misunderstood by the great majority of small customers, and for that reason, rate experts have been reluctant in recommending their use. It should be noted, however, that there is a growing tendency on the part of both privately operated utilities and those operated by municipalities, to arrange the rate schedules so as to more equitably distribute the costs.

The City of London recently adopted a schedule of rates based on the principles explained above, in connection with its electric lighting service. A large number of electric lighting companies,

and a somewhat smaller number of gas companies, in this country sell their product in accordance with a schedule made up in line with the methods referred to above. I do not know of any water-service schedules made up in the form which I have explained above.

I discussed this matter a few days ago with Mr. Cuddeback, another member of our committee, and he asked me flatly if I would try to impose such a schedule on any of the companies in New Jersey, and in answer I read to him an extract from a report on this matter which I made to the New Jersey Commission more than two years ago.

"In a situation such as existed in the town referred to, which was a seashore resort, where the method of computing minimum charges had already led to a feeling on the part of many customers that a minimum charge is not justified under any circumstances, it appeared that the public would not perhaps sufficiently appreciate the complexities of such a rate schedule as to warrant an introduction of a schedule rigidly based on the principles explained above. Nevertheless, the considerations adduced above led to the conclusion that there ought to be a minimum charge graduated with reference to size of meter and size of service used in connection with each customer."

MR. MORRIS KNOWLES * (*by letter*). The committee deserves much credit for calling attention to the fundamental factors which should govern the making of rate schedules. We may expect in the near future that there may be a substantial agreement on many of the perplexing problems affecting the fair value and a fair gross return for a public utility. It is necessary to remember, however, that such determination is a preliminary step, only, to the distribution of expense among all the rate payers, by just and equitable charges.

Owing to the difficulty of recognizing inequalities in rate schedules, there has not been so much study given to this portion of the general problem of valuation and rate making. And yet all who give the matter thought must recognize it as one of the most important and complex portions of that problem.

Our attention has been called to the old-time slide in rate

* Consulting Engineer, Pittsburgh, Pa.

schedules (frequently saw-tooth in construction), and more often a relic of some past copying from a schedule elsewhere in use and without any consideration of the propriety of application in a given case. It is important that we should understand that with a proper service charge (and the writer heartily agrees that this is the correct method of establishing a rate for the "Stand-Ready Service") then there is no particular advantage in the slide and there may be some positive disadvantages.

The writer would go further than the committee and suggest that in most cases there is no need of an intermediate rate but that there be two only; one, the standard general rate per unit of measurement, and another so low, if necessary, that the actual active costs of service only are met. The latter figure the writer chooses to call the "out-of-pocket cost," viz., that figure which if service were given at any less there would be a direct monetary loss because of not meeting actual operating expenses in proportion to quantity supplied.

It is this low rate, or "out-of-pocket cost," which the writer would particularly like to emphasize and to show the fallacy of the ofttime repeated assertion that such low rates constitute discrimination. He would also suggest that there are several reasons, in addition to those stated at the last paragraph on page 202 * et seq. for the use of a low charge in a sliding scale of equitable rates, and further that such smallest takers "*may even be profitable* to the system at low rates."

First, we may ask ourselves what are equitable rates, and, assuming that we have disposed of the question of fair value and reasonable return, we may define:

"Equitable rates are such as will assess the proper gross income upon consumers without discrimination, and with due regard for the public interest."

"Discrimination" is defined "differential treatment," and the literal application would seem to require that rates "without discrimination" should be based strictly on cost of service, without differential treatment according to amount of use, hours of use, kind of use, or any other distinction. It has been repeatedly

* JOURNAL N. E. W. W. A., Vol. 28 (1914).

decided, however, that this term does not preclude the classification of consumers and differential treatment of the classes, on any reasonable basis. Some extension must therefore be given to the literal meaning of the term, in order to make it workable, and while it has not been clearly formulated by the authorities, the "rule of reason" would appear to require that discrimination be defined as "differential treatment, except in so far as public interest requires."

Pursuing this line of thought a step further, we may come to the conclusion that there are but two grounds on which "public interest" may require differential treatment of consumers:

First, in order to secure some contribution to the public welfare — a method of indirect taxation of those against whom the differential treatment militates.

Second, in order to lower the cost to other consumers by retaining or securing custom which would otherwise be lost.

Some will no doubt contend that "with due regard for the public interest" has reference to the general welfare in such a way as to justify the lowering of rates on certain necessities to certain consumers, even to below cost, for the sake of extending the benefit connected with their use, or in order to encourage business, or for some similar reason. The argument appears to be that, while such steps have the effect of saddling a disproportionate share of the expense upon other services, or upon other consumers, it is nevertheless justifiable as a kind of indirect tax, and as in the public interest.

The writer sees no force in these arguments as applied to rate making. Indirect taxation is a useful part of our system of raising governmental revenue, but it should not take the place of actual governmental appropriation as a method of subsidizing any industry or service, no matter how desirable the encouragement of the latter is from the point of view of public welfare.

There remains, then, only the second basis as a proper reason for differential treatment of consumers — in order to lower the cost to other consumers by retaining custom which would otherwise be lost. How this works out may be very readily explained. Assume a small water works with a gross income of $35 000, which must be collected when it is supplying 1 000 000 gal. per day.

Now suppose one larger consumer, using 100 000 gal. per day and paying $3 500 per year, should find that he could secure water elsewhere at a cost of $2 500 per year, and should disconnect from the mains. The amount supplied would drop to 900 000 gal. per day; but interest, depreciation, and maintenance would remain practically the same; it would still be necessary to have the same number of engineers and firemen; and the only saving would be the small amount on fuel, coagulant, oil and waste, etc., which would certainly not be in excess of one thousand dollars per year, and would probably be a great deal less. So that the gross income to be raised might be reduced to say $34 000, all of which would have to be raised from other consumers. Now, if other conditions remained the same, and the rate for the large consumer were reduced so as to just hold his custom, when paying $2 500 per year, the total gross income would still be $35 000, and the portion to be raised from consumers other than the large one would be $32 500, or $1 500 less than in other cases. Their rates could, of course, be correspondingly lower than would be necessary if the large consumer were lost. The advantage of such an arrangement to the consumers is obvious, and such differential treatment, if necessary to secure this advantage, would not only constitute discrimination, as has been defined, but would appear to be a plain duty of the water works as a public utility.

In brief, it is to the advantage of all consumers that large, long-hour, high load-factor consumers be retained. Differential treatment of them does not constitute discrimination, so long as it will result in advantage and saving to other consumers. Such concessions in rates, however, must not be greater than actually necessary to meet the competition of other sources of supply. And, in any case, they must not be so great as to increase instead of decrease the income to be collected from other consumers. Thus in the case cited above, if it were possible to get the business at $2 500, any rate less than that sum would constitute discrimination. While if it were really necessary in order to meet competition, any rate greater than $1 000 per year would effect some saving for other consumers, and would be justifiable. A rate less than $1 000, however, would make the amount to be collected from other consumers greater than if the large consumer ceased entirely

to take service. This would certainly be discrimination under our definition.

The lower limit ($1 000 in the above case) below which rate concessions cannot be made, even if necessary to secure business, without constituting discrimination, and which represents the actual expense which would be saved if the consumer in question were disconnected, the writer calls the "out-of-pocket-cost," and its distribution over the quantity used by such consumer produces the rate to charge per unit of measurement. It has been found not only useful for fixing the lower limit of the proper total annual charge, but also in framing rate schedules.

As an illustration of how such lowered rate may be determined, the following may be of help. The cost of supplying water may be said to be made up, in the first analysis, of the "cost-of-readiness-to-serve," or costs which result from providing the plant and standing ready to serve and which are wholly independent of the amount of water supplied; and "output costs," which result from operating the plant, and which vary more or less closely with the amount of water supplied.

The "cost-of-readiness-to-serve" may be further subdivided into "capacity-cost," of which interest is the best example, which varies directly as the capacity of the plant, and may equitably be distributed to consumers in proportion to their demands, which together require this capacity; and the "service-cost," which varies with the number of services, and may equitably be assessed equally upon all services. Meter reading, billing and collecting are typical of this.

Similarly, the "output-cost" may be divided into two parts, the "out-of-pocket-cost," defined as above, and including all expenses for materials and labor used in small units and varying closely with the consumption, such as coal and alum; and the "remaining-output-cost," which includes expenses occurring in large units and varying somewhat with, but not directly as the consumption. Typical of these are the wages of pumping engineers and firemen.

In computing a rate schedule, it seems reasonable to divide the gross income into these four parts. The first two included in "cost-of-readiness-to-serve," the committee has properly placed

in the "service-charge." If no differential treatment were necessary, all the remaining costs would then be assessed by a uniform meter rate, obtained by dividing the total "output-cost" by the total annual metered sale of water. Differential treatment, in order to secure the business of favorable consumers who would not take water under these circumstances, might then be effected by relieving such consumers either of a portion or all of the "service-charge," or of a portion or all of the "remaining-output-cost," or of a portion or all of both. But it happens that the "service-charge," so calculated, is ordinarily a small part of the cost of water to the large, long-hour, high-load-factor consumer, to whom concessions must be made. Moreover, it would unduly complicate rate schedule computations to attempt to divide the necessary concession between the "service-charge" and the "meter-charge," and the writer has not, in his experience, met with any such case in which the possible concession in the meter rate was not sufficient or more than sufficient to get the business.

Conceivably it might be possible to classify consumers into groups by quantity used, location, or whatever reasonable basis made differential treatment necessary, determining for each group the cost of an alternative supply to which they would turn if concession were not made, and fixing in this way the extent to which it would be necessary and proper to relieve each group of a portion of the charge. But ordinarily this would be difficult or impossible and unnecessary, and it will usually be preferable to group all such large consumers, whose loss is threatened, into one classification, determining the extent to which it will be necessary to relieve the consumer most favorably situated with respect to an alternative supply, and either apply his rate to all large consumers, or, if he is very large, then apply a midway rate to others somewhat smaller in capacity.

Such computations cannot, of course, be established as theoretically precise, but improved accounting and good judgment will lead to results in which confidence may be placed as closely approximating the ideal.

There is one more thought which the writer would like to bring for consideration as a practical human factor, and that is that the "service-charge," or "minimum-charge" as it sometimes is

called, for the $\frac{5}{8}$-in. meters should include the cost of 2 500 gal. per month, or some such reasonable amount. This will not place out of balance the apparent uniformity of increase in "service-charge," and will forestall any possible criticism that metering will cause the small householder to be unduly frugal and that the use of water by the poor might be curtailed to a point below the minimum requirements of hygiene.

Mr. Coggeshall. Mr. Chairman, I want to say in corroboration of Mr. Lockridge's statement about the municipal buildings that we have been fortunate in the last five years in having meters installed. In our city, now, every service is a metered service.

All the public buildings and all the public supplies except fire hydrants and sprinkler supplies are metered, and each department pays from its own fund just the same price — 15 cents a thousand gallons — as every other taker does in the city, with the exception of manufacturers; they have a rate of 10 cents a thousand gallons. One schoolhouse, formerly using — or mostly wasting — $3 500 worth of water per year, when no charge was made, now uses about $200 worth.

Mr. Charles W. Sherman. There is one point in the committee's report which I am inclined to wish had been expressed a little differently. That is, in the item about obtaining the service charge, "An amount which will represent the approximate average value to the works of the water that passes a domestic meter without being registered."

This portion of the "service-charge," — as I look at the problem, — what this third part of the service charge should cover is the cost to the system of the water unaccounted for, and the unaccounted-for water isn't by any means all going through the meters without being registered. I admit, of course, that a part of it is; and it may be that the result arrived at by the committee is substantially what would be reached in the way it would occur to me. But, nevertheless, the fact remains that the leakage from the main pipes and any other unaccounted for water represents a cost to the works which must be divided among the water takers, and which ought to go into making up this particular part of the service charge.

The matter comes home to me especially from our experience

in Belmont during the past year. We have succeeded in reducing the unaccounted-for water from approximately 33 per cent. to about 28 per cent. in the course of one year, and as far as we know that reduction is substantially all in small leaks in the main pipes. It means, of course, a great deal of careful work on the part of the superintendent, and unceasing vigilance in finding and stopping the small leaks. But there is no reason to believe that the saving is due in any appreciable measure to greater accuracy in the metering of the house supplies. For those who do not know, I will say that it is a 100 per cent. metered town, and that the water is metered to the town by Venturi meter; all of the water used is carefully accounted for. There is practically no street watering at the present time, on account of oiling the streets. The water used for sewer flushing is metered; when the gang goes round to flush the sewers, the water department puts a large meter on the hose with which they do the flushing; and the amount of water which has to be estimated is hardly more than that lost by filling new pipes and flushing dead ends.

Of course the above percentage accounted for is nothing to boast of. I quote the figures merely as an indication of the importance of main pipe leakage as compared with water passing house meters without registering.

Mr. D. A. Heffernan.* Mr. Sherman has spoken about the consumption of water in Belmont. I do not want to let this opportunity go by without telling the conditions in the town of Milton. The town of Milton is one hundred per cent. metered. During the year 1914, the water measured —

By Venturi meter was	103 549 000 gal.	
By Metropolitan Avenue meters	17 410 359 gal.	
Total	120 959 359 gal.	
Registration of house meters	101 516 690 gal.	
Unaccounted for, or waste	19 442 669 gal.,	or 16 per cent.
The average daily consumption is	331 396 gal.	
Gallons per day to each inhabitant	38.6	
Gallons per day to each consumer	41	
Gallons per day to each family	183	
Gallons per day to each tap	188	

* Superintendent Water Works, Milton, Mass.

We have about fifty miles of cast-iron mains.

MR. R. D. CHASE. I would like to submit a table of the results in Fall River. It is divided into the various items, and then at the end the amount unaccounted for, which runs in various years from about 14 to 16 per cent.

PER CAPITA CONSUMPTION FOR VARIOUS PURPOSES, 1914.

Purpose.	Gallons per Capita.	Per Cent. of Total.
Sold — Manufacturing purposes	6.46	13.20
Sold — Domestic purposes	21.48	44.00
Schoolhouses	2.02	4.14
Public buildings	1.37	2.81
Parks and cemeteries	1.19	2.44
Street watering	2.74	5.65
Flushing sewers	.46	.94
Puddling trenches	.32	.65
Fires	.53	1.09
Maintenance Water Department	4.12	8.45
Overflow waste — back to lake	.70	1.43
Unaccounted for	7.41	15.20
Total	48.80	

Based on population, May 1, 1914, 122 231.

Year.	Daily Average Consumption. (M. G. P. D.)	Daily Average per Capita. (Gals.)	Amount. Gals.	Sold per Capita. Per Cent. of to Total.	Amount Unaccounted For, per Capita.	
					Gals.	Per Cent. of to Total.
1905	4.40	41.34	24.65	59.75	6.46	15.65
1906	4.47	41.49	24.79	59.80	6.02	14.62
1907	4.94	43.93	25.79	58.75	7.56	17.25
1908	4.96	43.48	27.25	62.80	6.26	14.44
1909	5.34	46.40	25.00	59.00	5.84	12.60
1910	5.20	43.59	25.90	59.40	5.04	11.55
1911	5.17	44.09	26.30	59.75	6.24	14.15
1912	5.33	46.23	28.19	61.00	4.97	11.78
1913	5.63	47.04	28.10	59.70	5.62	11.94
1914	5.96	48.80	27.95	57.25	7.41	15.20

MR. W. C. TANNATT, JR. Mr. Chairman, there do not seem to be many friends of the flat rate, but after hearing the discussion

by Mr. Morris Knowles I cannot help thinking of the experience of Easthampton. We went after the big business, and allowed a rate where we felt we were making the cost of production. The big business found that it was such an item to them that in a few years that class of construction grew so that the system had to be enlarged. The enlargement practically equaled the cost of the former system, and when we attempted to charge the big consumers at the mills a fair proportion of the cost of the enlargement we lost the business. I can see where a system that has been figured with a large factor of safety can very well go at the big consumer with a small rate, but if the system is figured anywhere near up to the capacity of the town, it is a question to me whether they have a right to do it, whether it will be policy.

MR. CHARLES N. TAYLOR.* The minimum rate in Wellesley is $6 for 16 000 gal. of water, or 37½ cents per thousand gallons. Any water that is sold or used beyond this amount is sold at the rate of 25 cents a thousand gallons, whether they use one thousand or one hundred thousand gallons. To my knowledge the town has lost only one customer by the rate being too high, but that was a very good customer. If the town had that customer to-day it would be receiving more than $10 000 a year additional revenue.

The point which interests me most in this discussion has not been touched upon, and that is the charge for water to summer residents in localities that are occupied only about four months in the year. If water is metered to the summer takers, unless there is a minimum price, there is not sufficient revenue to pay the interest on the investment. How should water be charged for in such cases? The cost of laying the pipe to the summer cottages is just the same as it is to the permanent residences, and pressure has to be maintained in the pipes the year round in order to give the cottages fire protection. The investment on the pumping machinery and the standpipe and everything is just the same in both cases. But if you undertake to charge the summer people the same price for the use of the water for a few months that you charge for a year you are called a robber and told that it is not fair.

MR. HEFFERNAN. In the town of Milton we have a minimum charge of $12 per year, and if people go away in the summer and

* Contracting Engineer, Wellesley, Mass.

have the water shut off in the street, a rebate is made, providing the water is shut off for four months, the minimum charge being pro rata from the time the water was turned on.

MR. TANNATT. Mr. Chairman, that would do very well when only a few go away, but where more than two thirds of the people are summer visitors, it would reduce the revenue to almost nothing.

MR. HENRY A. SYMONDS.* Mr. Chairman, I would like to call the Association's attention to a bill before the legislature at this time which deals with this particular subject. It says:

"All corporations and companies engaged in the distribution and sale of water in this commonwealth and occupying the public streets with their mains and pipes for that purpose shall not, where water is supplied for domestic service to a consumer for any period of six months or less in any year, charge such consumer a sum greater than one half its annual minimum rate for like services."

I think that while this speaks purely of corporations and companies, there are represented in this Association a large number of water companies. Whether this particular policy is advisable for both public and private water works, I think should be looked at from the standpoint that what is fair in one case is apt to be fair in the other.

In regard to the question which Mr. Taylor asked, the establishing of rates in shore places has come to my attention a number of times, where there was purely a summer population and where the income during the winter months was almost nothing. The way we have solved it, or tried to solve it, has simply been by charging the yearly rate for those places. That has in general been satisfactory after the matter was thoroughly understood. Of course, as has been pointed out, the full investment must be made in order to take care of that service, whether it is for three months or whether it is for twelve months. About all the difference it makes to a company or to a town when they supply a section of that character is the little extra fuel required for pumping during the remaining period. The same organization practically has to be maintained right through the whole year. In a shore place every one who comes there for three months is in-

* Boston, Mass.

creasing what is the maximum capacity of the plant or the demands on the plant, and it seemed to us that while there is a certain point of view where it is a fair proposition, from the company's or the town's point of view it is hard to see how to get round that proposition except by a yearly charge.

MR. CUDDEBACK.* It seems to me that the rates suggested by this committee are particularly applicable to a case of just this kind, where there is a service charge which includes no use for water. That service charge would be applicable to a house whether it is occupied for three months, four months, six months, or a year, and then a charge for the water based on the other expenses. That would of necessity mean a meter rate. And then there should be a charge for removing and resetting the meter to take care of that expense.

MR. HAZEN. Some of the members think that the same rate ought to be paid by everybody, and by the schedules that they have drawn some members seem to think that there ought to be fifty points of slide; and all points of view between have been expressed, either in the discussion or in the schedules. The committee thought that a compromise perhaps of a scale with three slides was the best to adopt at this time, and it would be understood that those who do not want the slide are at perfect liberty to make the three rates the same, in which case the slide disappears and they have the full rate. That is fully provided for in the schedule. But on the other hand the committee does believe that there is oftentimes a legitimate difference, an actual difference, that cannot be overlooked, between the conditions of service to small consumers and to large consumers, and that the sliding scale has an inherent reason for existing and it cannot be altogether pushed out of the business at this time.

The great majority of consumers come under the domestic rate in the proposed schedule. I have just been through the records of a smaller plant with about 5 000 services, and in them I find that instead of the 92 per cent. that Mr. Lockridge finds in Springfield, fully 97 per cent. of all the services would come under the domestic rate, and of the rest more than 2 per cent. would come under the intermediate, and only a small part of 1 per cent. under

*Engineer and Superintendent, Passaic Water Company, Paterson, N. J.

the manufacturing. But notwithstanding that, the 20 services under the manufacturing rate take 35 per cent. of the water, and so what you are going to do with these few services is a very important condition.

In regard to Mr. Sherman's question I would say that the committee did not take the matter up from the standpoint that he suggested, but they did take it up from the standpoint which they stated. The question of the unaccounted water in the system was not taken up by the committee in any way. It is a perfectly proper matter to take up, and the committee probably would have taken it up if they had had more time and more statistics, but they did not get to it.

Mr. Knowles' and Mr. Betts' discussions run along something the same lines. I am particularly struck by Mr. Knowles' expression for this less-than-cost kind of services which he thinks water-works plants ought to adopt at some time, and I am interested to note the peculiarly expressive phrase which he used to express it. He called it the " out-of-pocket " charge. Now, it is the first time that I ever heard of any one who wanted to get " out-of-pocket " business. As far as I know, we are all looking for " in-pocket " business. I think the expression is an apt one, but if it were applied to the company which Mr. Betts gives some statistics of in New Jersey, and if that company — which I think I know something about, if I am not mistaken in his discussion of it — could develop a large thriving business at the rates he suggests, I do not think anything could happen to put them into bankruptcy quicker. Nevertheless, it is an interesting theoretical discussion. It goes to show that all sides of the question have to be considered. When a plant is over-built and wants business, it is in one condition, and consideration of those conditions alone would result in one schedule of rates. When it has grown pretty nearly up to capacity and needs to be extended, the conditions are different, and consideration of what is happening then would lead to an entirely different scheme of rates.

Now, it is my feeling that a water rate, to be a fair rate and a good rate, ought not to apply to either of those extreme conditions; it ought to be a rate that will work year in and year out and at which the business can be done and expenses met, and — in the

case of companies, at least — a reasonable profit earned. With that in view I do not think that we need to go very far on the out-of-pocket rate growth.

There is one matter which I should like to speak of, — the question of gallons or cubic feet. I think you can help us on that. There is a very good discussion here which I will read, and then I am going to ask the chairman if he won't take an informal vote of the members of the Association present as to their preference between gallons and cubic feet. And after that it is my thought — after this meeting is perfected — that your committee will try to digest another meeting and will make a final report of the schedule which they will recommend to the Association for adoption, and which I hope will be in shape so that you can adopt it and that it will aid in bringing order into this complicated matter.

This discussion which I am asked to read is from Mr. Schwabe. *

I am convinced from experience that gallons in dealing with the consumer is the better unit to use. I find it much easier to talk with a consumer on his water consumption in gallons than in cubic feet, and find the customers have greater confidence in meters and in our statements, as they can readily check up their meter readings and make tests themselves.

The public buys all liquid commodities by the gallon unit, which is a point in favor of supplying water on the gallon unit. Pumps, standpipes, etc., are all rated on gallon capacity, and I firmly believe that the gallon should be commonly used as a unit for the sale of water, as it is the standard unit for liquid measurement, while a cubic foot is a unit of volume measurement irrespective of what the consistency of the volume is.

The argument that other commodities, such as gas and electricity, are measured in units that are foreign and not understood by the layman is no excuse for using such a unit for the measurement of water when there is a better and commonly understood unit that can be used.

If there is no objection, Mr. Chairman, I think it would be well to ask a rising vote on the preference of the men present as between gallons and cubic feet.

THE CHAIRMAN. Mr. Hazen has requested that the gentlemen

* President and General Manager of the Thompsonville Water Company.

express their feeling as to whether the meter should have dials reading in cubic feet or in gallons. All those in favor of cubic feet will please rise. [Seventeen members rose.] All those in favor of gallons please rise. [Twenty-three members rose.]

It seems that most of the members are in favor of measurement by gallons.

MR. WALTER P. SCHWABE. Mr. Chairman, I was not sure that I was going to be here, and that is the reason I wrote that letter about the gallons and cubic feet.

I want to say that in Thompsonville we are just going over to the meter system of charging, and it might be of some value for you to know that we will not bill less than tenths of a thousand gallons; in other words, not less than a hundred gallons.

The meters are equipped with a straight reading register; the zero on the register plate and the figures on the wheel indicating tens are in red, the balance in black. Meter readers will read the black figures only. These figures will be used for billing, so many thousands and hundred gallons. The dials with red figures are only necessary for test.

MR. FRANCIS W. DEAN. Mr. Chairman, in regard to this vote, while the result is interesting, it seems to me that there are so few members here that the vote really does not mean much. Now, while I think it would be well to find out what the members of the Association think, I feel that a vote should be taken when there are more people here, or else a letter ballot be obtained.

As for me, I think that the users of water know enough about feet to know what a cubic foot means. That quantity of water ought to be pictured on the imagination of a person just as thoroughly as a gallon. I think more accurately so.

MR. F. N. CONNET.* Mr. Chairman, twenty years ago about 90 per cent. of the orders for Venturi meters specified "cubic feet" graduations for the counter dials, but to-day about 95 per cent. specify "gallons" instead. I am referring to meters for municipal water works only, because "cubic feet" are universally used for large meters for water supplied to turbines and for irrigation purposes.

THE CHAIRMAN. I take it that this is an informal vote, a sort

* Chief Engineer, Builders Iron Foundry.

of index for the committee. I may say that I have seen at times mild amazement on a consumer's face when objecting to paying 15 cents per hundred cubic feet. He cannot seem to understand or grasp what a hundred cubic feet is, and mentally he tries to figure it out. At times the cubic foot would appear as foreign to him as a cubic centimeter, but when the consumer was told that a hundred cubic feet was equivalent to 750 gal., he certainly looked amazed and relieved. The ordinary water taker who keeps tabs on his water bill does not understand the unit cubic foot or have any conception of its equivalent in gallons.

MR. CALEB M. SAVILLE. The results of the studies of this committee are a most valuable addition to the literature of waterworks operation, and this Association is to be congratulated in having members of such high professional standing who are willing to give of their time and experience for the preparation of such an important subject.

In spite of the fact that I seconded the move to accept this report at the last meeting of this Association, I am very glad that final action was postponed. On more careful consideration of its provision, it seems to me that the report does not fully recognize some conditions which are very important.

Many service connections are made entirely for "ready-to-serve" purposes, and comparatively little water is used.

With the high meter rate and low service charge, this class of consumer is not paying its share of the water department expense. In other words, the constant consumer is paying for the protection of the chance customer.

The arbitrary separation of service charges into three divisions, it seems to me, does not allow that elasticity in making rates which can apply immediately to the small domestic consumer on the one hand and the large manufacturing establishment on the other.

Local conditions vary so greatly that it appears unwise for this Association to go on record as absolutely being in favor of the adoption of any particular rate scale without more information before it as to other scales that might be of advantage under certain circumstances. If it is practicable, I would like to see in the summary of a report reference at least to several variations of assessing meter rates which might be adaptable to local conditions.

I believe that a hard-and-fast standard is not practical of application to the needs of all water departments. For example, it seems to me that the schedule proposed might not apply to a small system when all of the consumers except one are "for domestic purposes" and the exception is a large manufacturing plant which has its own supply for ordinary occasions, but uses its public supply only as an auxiliary to keep down its fire insurance rates.

Such cases are not at all uncommon, and, due to the requirements for fire protection, a large burden is put on the water department without adequate return under the schedule here recommended.

It is recognized that it is almost impossible to draft a schedule that will be of universal application. In its preliminary report the impracticability of strict adherence to the proposed schedule was met by the statement that the schedule proposed was an "ideal one to be worked toward." Personally, I would not like to see this Association accept the recommendation of this committee as *the ideal* without further discussion.

MR. A. E. WALDEN (*by letter*). Would it not be better, before a final decision is reached on this subject, to submit tabulated figures as to the water rates obtained from the various companies, together with a rough outline of their systems; that is to say, a brief statement as to whether they are purely gravity supplies or are being pumped either by water or steam, and whether or not all the supplies are filtered, together with pressures carried. It would seem that this would allow the various companies interested to form some conclusions as to what rates were fair as between the various companies and systems.

DISCUSSION AT MEETING OF MARCH, 1916.

MR. CALEB M. SAVILLE. I would like, Mr. President, to move that this matter be postponed for further discussion, or be postponed before being finally accepted, until the first fall meeting; and that the committee be asked if they will submit such other methods of assessing rates as they had under consideration when they proposed this one.

THE PRESIDENT. You have heard Mr. Saville's motion.

A MEMBER. Second the motion.

THE PRESIDENT. It is now open for discussion.

MR. H. V. MACKSEY.* Mr. President, if you were confining the discussion strictly to the motion before the house, I should oppose the motion; because as it was put, it seems to me to defeat the main object of bringing this question up to-day; it was cutting off discussion by the members. It appears that what has been going on — a free discussion of the report of the committee — should be encouraged; and after that it is proper to hand the report back to the committee and let it consider our view of its action and possibly it may then decide to modify the report.

I take it for granted that, because all the members of the committee signed the report and there is no minority report, all the members are in favor of it. I think we must assume that, on the facts before us. And while I do not agree entirely with the report of the committee and feel that the gentleman from Holyoke has the right idea, — that we should sell metered water at a flat rate, — I doubt if it is practical at this time to do so in all cities as is done in Holyoke. There is a tendency in all cities to encourage the manufacturer by giving water at cost or less than cost, and letting the little fellow pay the freight, but it is something that we should oppose at all times. We should try as far as possible to keep the rate up for the large consumer, and give the same rate to the small consumer.

There is a point that I believe is not touched upon in the report of the committee; that is the fire service, the service for fire protection only. In the majority of cities there is no charge at all for fire service. Water departments and water companies should be willing to help in a great emergency like a fire, and do so without charge, but, if we are attempting to run municipal water works like business institutions and separate from all other municipal activities, they should not be asked to supply the appurtenances for that free service without charge, as is being done in many cities. Some consideration should be given to fire service in this report.

The form in which we are asked to report is excellent. The

* Superintendent Public Works, Woburn, Mass.

ideas which the committee have offered in regard to classifying services and charges therefor are very good. I hope that all the members present will voice their opinions to-day, and that after that the motion before the house will prevail. If the membership gets more information from the committee, and has more time to think it over, perhaps in the fall it may be able to give some assistance to the committee.

Mr. President, may I be allowed one word more. I would like to say, after listening to the last speaker, that I think possibly his view is limited. In the little city that I am connected with at the present time, we have another use for water. I refer to the truck farm, where a farmer asks for a 2-in. service. At times he wants much water, a greater part of the time he wants very little water, and during the winter practically none. We are carrying on that farm business for him, and the little fellow who works on the street is asked to help to pay to carry on the farmer's work.

It is the old view that the water department must help the city as a whole; if it is able to extend a pipe, never mind if it does not bring any revenue to the water department, — think of increase in valuation! But does the water department get any of that increased valuation? No. All that increase in valuation helps the mayor to decrease the tax rate. The water-takers as a class should not be taxed to support the real-estate owners or the manufacturers as a class. We desire a square deal, as they do in Holyoke.

Mr. Edwin C. Brooks.* Mr. President, isn't it a fact that large industries in locating their plants have regard to the labor market more particularly than to the cost of water; and does any manufacturing establishment use any more water than it is obliged to in its business?

Mr. R. C. P. Coggeshall. Mr. President, Mr. Macksey has just raised the question that I was on the point of introducing. Why not consider the introduction of a charge for standing ready to deliver on the sprinkler service, for which there is now no charge? It seems to me that that is a service which ought to be recognized.

The President. Do you ask that question of me? I

* Melrose, Mass.

would say that I find that if manufacturers can obtain water from any other source than the water department they will do so, — if they believe that they can get it more economically that way. That brings up the old question of the protection of the primary water supply from the secondary water supplies. I can say also that I guess the water question would not bother the munition manufacturers of Holyoke or Bridgeport at the present time, if they could get help.

Mr. Coggeshall. Mr. President, perhaps a little résumé of what has happened in New Bedford may in a way answer that question. Previously to 1909 the rate for manufacturing purposes was ridiculously low; viz., $2\frac{1}{2}$ cents per thousand gallons. That rate was influenced by reason of the bequest of Sylvia Ann Howland, the aunt of Hetty Green, who gave the city $100,000, the income of which was to be used in encouraging the introduction of manufacturing. When this bequest was made, the city was small and there was only one corporation of three mills located there. You are all witnesses to the fact that New Bedford has now grown to be one of the largest textile manufacturing centers in the country.

In 1909 we were influenced by the example of Holyoke; all schedule rates of every kind were discontinued and a single rate of fifteen cents per thousand gallons for metered water was substituted for every use. Then came the argument that Sylvia Ann Howland had left that $100 000 to encourage the introduction of manufacturing; and on the strength of that they finally deemed it wise to place the manufacturing rate at ten cents, leaving the fifteen-cent rate for all other purposes. The manufacturers vigorously protested and predicted the decline of New Bedford's prosperity. They declared that the ten-cent rate would prohibit the introduction of additional mills. This has not proved to be true. Many new mills have since been added; there are three now going up. And, mark you, New Bedford is about the only large manufacturing city that does not have a secondary supply of fresh water aside from the city water. Every mill there has got to take every drop of water from the city of New Bedford.

Mr. Frank A. Barbour.* Mr. President, in recommitting

* Consulting Engineer, Boston.

this report, I believe it would be well to suggest to the committee that, since its final report will stand as the expression of the present position of this Association in regard to meter rates, it should include more definite statements of the conclusions reached in reference to a "flat rate," and the feasibility of assessing in the ratio of frontage or valuation a part of the cost of the system.

The report as now submitted recommends a sliding scale of three divisions with limited amount of slide — the manufacturing rate to be very seldom less than one half the domestic rate. In the progress report of 1914, a reference was made to the question of a flat rate, but it would seem that this Association, if it desires to lead, should more definitely express its conclusions for or against a flat rate, and without such definite treatment of this phase of the problem, it is doubtful if this Association should put its seal of approval on the report of the committee.

Again it would appear that the question as to the advisability of assessing some portion of the cost on the basis of frontage or valuation so to express the benefits received by property owners, regardless of the actual use of water, has not been as well developed as might be the case. This phase of the subject was carefully considered by the 1905 committee, and should be more definitely negatived or approved in the present study of the problem.

As a general statement, approximately one half the average water-works plant is chargeable to the provision made for fire protection — the benefits from which are perhaps more nearly in the ratio of property values than any other assessable unit, and have little or no relation to the amount of water consumed. The law in Massachusetts in regard to sewers requires that at least one quarter of the cost shall be borne by the town or city on the basis of valuation, and it is difficult to understand the logic of throwing the entire cost on the consumer in the case of water works.

It may be that a flat rate is not generally practicable, but the recommendation of the committee that higher rates may be properly charged in the higher districts to meet the expense of the greater pump lift, is a step too far in the other direction. Where is the line to be drawn, and why not charge more in those districts where the trenches are in rock, than in those where the prevailing

material is earth? Why should elevation be made a greater factor in determining cost than the character of the ground encountered?

The last word of this Association on meter rates will be given great weight throughout this country, and the final report of the present committee should consider and discuss, in the broadest possible manner, all moot questions, and should — so far as practicable — point the way towards the ideal, and this without too great regard for present methods.

MR. CHARLES W. SHERMAN.* Mr. Barbour's suggestion of the value of the water-works system to the entire community, and the portion of the running expenses or the fixed charges, or both, which should be met out of general taxes, is, I believe, well worthy of consideration. But if it is taken up, the committee must also consider, as an offset against it, the value of the exemption from taxes which a municipally owned water department enjoys in every case in this state except Holyoke, if I am not mistaken, and probably throughout the country. We hear very little about the value of this exemption from taxes. In one case in which I had occasion to make approximate figures, a short time ago, I was surprised to find that the value of exemption from taxes was very close to the value of fire protection.

THE PRESIDENT. If this motion prevails, Mr. Sherman's suggestion, and Mr. Barbour's suggestion, and every suggestion, will be written out and forwarded to the committee.

MR. S. H. MACKENZIE.† Mr. President, I agree with the gentleman who has just spoken. I believe that there should be a charge of some kind for fire protection. When the charge is included in the water rates, in many instances, it will place the burden where it does not belong, as many times the largest consumers of water have the least property to protect. Value has been given, and the property benefited should stand the cost in accordance with the benefit derived.

The one-rate idea is certainly fine, and should be our ideal, but there are a great many local conditions which prevent its adoption. There is no doubt that many of the old-time complicated rates

* Of Metcalf & Eddy, Consulting Engineers, Boston.
† Water Works Engineer and Accountant, Southington, Conn.

can be simplified and some form adopted which will make comparison easy and the keeping of records less complicated.

When considering the new meter rates, the service or ready-to-serve charge should be taken into account. The services should be paid for by the property owners, as they are for their exclusive use. The ready-to-serve charge should be the expense less proper deduction for fire protection which is incurred whether water is consumed or not; but at the present time it does not seem practical to put the whole expense under that head, as it places a burden on the small user, so that it seems wiser to include part of the charge in the water rate and in that way divide the balance of the expense in accordance with the water consumed.

Five years ago our department at Southington, Conn., adopted practically the system of rates recommended by your committee, except that the service charge is included in the rate for the first one thousand cubic feet of water.

Our rates are as follows: $\frac{5}{8}$-in. meter, \$0.50 per quarter and increase according to size of meter; ready-to-serve charge, \$1.00 per quarter, included with charge for first 1 000 cu. ft.; first 5 000 cu. ft. at \$1.50 per thousand; next 95 000 cu. ft. at \$0.60 per thousand; all over 95 000 cu. ft. at \$0.40 per thousand.

The above has proven satisfactory, although I believe the low rates are lower than we can afford to furnish the water when we have to increase our supply.

If we adopt the single-rate idea just recommended by our friend from Holyoke, and made it low enough so our factories would feel they could use the water, it would materially reduce our income and would be below what we could furnish our small consumers for, as we have an average of about 145 ft. of main to each service. Selling our surplus water to the factories at the low rates mentioned is a material help to our small consumers. It does not seem to me that the postage-stamp theory applies to water departments. We all pay two cents each for postage stamps, whether we buy one or a thousand, but each stamp has a separate duty to perform. It does not make any difference whether it is on a letter mailed by me or on one of a thousand mailed by a factory: each letter is handled separately and delivered to a different person, and therefore should pay the same for the service;

but, in the case of water, 10 cu. ft. a day is delivered to my house, while a factory takes 2 000 cu. ft. through a pipe of the same length and size as used to carry the 10 cu. ft. It certainly would cost much more to deliver and collect for 2 000 cu. ft. to two hundred consumers than to one.

I certainly appreciate the work the committee has done. The chaos under which meter rates have been struggling is giving place to light. Let us have a little more free discussion before coming to a final report.

Mr. Morris Knowles.* Mr. President, I did not at first think favorably of such a motion to postpone, — meaning as it does postponing until the autumn meeting; and yet I now find myself in this position, that I would like to second that motion and briefly state the reasons.

It is true that any schedule or rule is capable of a number of different applications. The committee has very nicely worked out in detail one thought; it is not the only thought with regard to the making of rate schedules. There are several others which are receiving attention all over the country at the present time. I doubt very much if we realize here in this room how a report of the committee of the New England Water Works Association is taken as "gospel truth" even in other parts of the country remote from New England; and if it should appear that the committee had not presented in its final report the suggestions, the recommendations, the arguments, pro and con, for the various methods, before finally stating the conclusion as to why one method was desirable, it would not and should not carry the kind of weight of which we are especially proud.

Then again, when this report first came out, in September, 1914, discussion was requested; some written communications came in, but for some reasons this has not been printed — it is not before us for our consideration at this time. Is it not a matter for the membership at large to decide, whether such subject should be decided without all the information before us? I speak, of course, with entire respect for the membership of the committee. It is probable, however, that, if this be referred to the committee again, they will not become discouraged and think we are turning down

* Consulting Engineer, Pittsburgh, Pa.

things they have done, but will adopt the suggestion of Mr. Saville and bring to us the arguments pro and con regarding the various kinds of schedules.

I myself would feel very strongly that an amendment of this schedule perhaps might be adopted at this meeting; but it seems to me that even that would be undesirable, as we do not have the information before us that has been suggested in the discussions. There are other things that are being thought of over the country. Therefore I do join in the second to the motion of Mr. Saville; and hope that the matter will go over, with the intent that the discussions may all be brought before us, and that the committee may add to the final report the various considerations and arguments bearing upon the use of different schedules in different places.

MR. J. M. DIVEN.* There can be no question about private fire services being of value, but available only to the few; so why should not those who receive the benefits pay for the service? It does cost the water works something, something for inspection and something for "readiness to serve." The benefits are reduced fire risk and business interruptions from fires and reduced insurance rates. It is good business policy to encourage factories and to give them every reasonable concession; factories help the town and every inhabitant, and they are entitled to lower water rates; but should pay for such a special privilege as a fire service for their sole benefit, for not to make such a charge would be to discriminate against the water takers not having such special protection.

MR. HUGH MCLEAN.† Mr. President, I am in favor of the continuance of this discussion to another meeting. We want to know the views of those present relative to the proposition.

It seems to me that to have three rates is the opinion of this organization, and to go out before the country as the report of this organization is a step in the wrong direction.

I have related before my experience with the three rates, and that I think they work an injustice to the small consumer. We set out, about some eight or nine years ago, to abolish the three rates in Holyoke; and we established one flat, uniform rate. For

* Superintendent Water Works, Troy, N. Y.
† Water Commissioner, Holyoke, Mass.

the men's names that are attached to this report to go out before the country and to say that it is their opinion that three rates is the best, they are turning away from the average thought of equal rights to all, special privilege to none. When we assess the valuations of a city, we do not give the large owner a special rate; he is assessed just the same as the small property owner. Why should the large consumer of water get a special rate of five or six cents a thousand gallons, and the small consumer have to pay all the way from fifteen to twenty cents a thousand gallons? Wherein is that justice? Is it not discrimination? Is it not contrary to the advanced thought of legislatures and government of to-day, — that equal rights and special privileges to none shall prevail? It seems to me that the minds of those present should be expressed on this subject, and that if we are going to recommend something for the consideration of our members throughout the country it ought to be more nearly along lines of equality.

I do not know whether or not this is a unanimous opinion of the gentlemen who have studied this report, or whether there is a division amongst them as to the wisdom of it. But personally I have felt that I would be doing an injustice to myself and to my colleagues in our desire to perfect a rate, if I did not voice my sentiments. In Holyoke we have successfully adopted a one flat rate to all, regardless of whether they use a thousand or a million gallons, and it is working splendidly. Now, wouldn't it be better to take a step in that direction, have only two rates, rather than to be going away from it and to have three? Eventually a cry and a demand will be made that the small user is entitled to water at the same price as the big user, because water departments are established primarily for the benefit of the small users.

I do not want to be classed as radical, but, nevertheless, I feel very strongly on this matter, after going through it as we did in Holyoke. When we had the three rates it was a vexing problem all the time; there was a continual demand for the change of the rates, and our Water Board worked on it for four years, till we abolished the three rates and took two, and then we finally abolished the two and took one. It seems to me that if we recommend this report to the country we are taking a step in the wrong direction.

In regard to the matter of charging the fire department for water, we have a flat rate, I think, of eight dollars a hydrant. We charge every department for all the water they use, and we pay a tax like every other corporation.

If we are going to recommend something, it seems to me that we ought to try to get the best. The United States Government does not have three rates; if you buy postage stamps, whether you buy one or two or a thousand, it is the same price. Why the fallacy of having special privileges and special water rates? We are advanced beyond that. It seems to me that a step in the other direction is the step that we men who meet each other and study those problems should advance.

MR. COGGESHALL. Well, isn't it a fact that this report allows any city to establish a flat rate?

MR. MCLEAN. Yes. But the principal recommendation is that of the three rates.

MR. MCKENZIE. Mr. President, I would like to ask the gentleman from Holyoke if they have a minimum rate, or any way in which they can take care of the small consumer. Do you have a minimum charge of any kind in Holyoke, or is it a flat rate for the actual water consumed without regard to the quantity?

MR. MCLEAN. Yes, we do.

MR. CHARLES W. SHERMAN. It seems to me that there is a great deal in what Mr. McLean has said. If I correctly understood the opinions of the committee at the time the original report was presented, they felt that there is a good deal to be said for the single rate. In my own town that is the practice; we have but one rate for water.

I believe with Mr. McLean that the fewer the classes into which the rates can be divided, the better off we are, as a rule. There may be, and doubtless are, places where for reasons of policy, or for other reasons with which local conditions may have more or less to do, it is not wise at present to come to a single rate, and possibly not to two rates.

If the committee's report should be adopted, it would be a step in advance, in reducing the number of classes — which may be as many as eight or ten in some cases now — to three, which of course would be a material gain; and any communities or water com-

panies which found it possible to make the number of classes two, or even one, would be so much the better off.

MR. PATRICK GEAR.* Mr. President, in answer to the gentleman who asked if we had the minimum rate in Holyoke, I will say that we do have for tenement blocks. If you are fortunate enough to own a block, with four or more tenements, we will gladly put you in a meter for the sum of five dollars. We allow for said amount eighty-two thousand gallons of water a year per family. The only minimum rate we have is for tenement blocks. The manufacturers and others pay for the quantity of water used.

In some of the mills where pumps are in use, we have set meters, and the quantity of water used by them does not pay our department one dollar; they want a meter in case their pump should give out so that they may be able to get city water. The meter is put in and we get the rental charge on same. I am in favor of that part of the report which says for that kind of a service we should receive some return besides the rental charge on meter.

Yesterday up in Holyoke there came to my notice a case in which a man had a 3-in. meter set in his building and very little water being used; the rental for this meter was $16.00 per year and the quantity of water passing through this meter for last year, the year before, amounted to about $12.00. This man kicked on the rental charge and asked for a smaller meter. The tenant on the top floor of this building where the meter was set used an elevator, run by water, to carry up his goods. After the smaller meter was put in, the tenant lost so much time by the slowness of the elevator in carrying up his goods, he was obliged to move out and by so doing the consumer gained $2.00 and lost a good tenant.

Our people in Holyoke think that we have the finest meter and water system in the world, and anybody that does not agree with us has not the right idea.

Everybody knows that it is the small workingman who is paying for the water, and he is the one that is supporting it. The big fellow will use driven wells if possible. At one time we sold water for three cents per one thousand gallons, and we are now selling if for five cents, and yet they are putting in wells where possible. We sell water as cheap as you will find anywhere, and yet the

* Superintendent Water Works, Holyoke, Mass.

manufacturers are not coming to our city as in former years. They will tell you that the large consumer is the most desirable tenant, but I say that the smaller one is just as desirable, because we have more of them and therefore all should be treated alike and given a flat rate.

PROCEEDINGS.

Executive Committee.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Tuesday, August 8, 1916, at 10.30 A.M.

Present: President William F. Sullivan, and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, Edward C. Sherman, Lewis M. Bancroft, Willard Kent, Albert S. Glover, and William S. Johnson, the two latter being present by invitation.

It was voted, on motion of Mr. Bancroft, seconded by Mr. Saville, that additional room at headquarters be secured for our Association at an expense not to exceed $150 (one hundred and fifty dollars) per annum.

It was voted that the President be authorized to appoint a committee to act with a similar committee of the Boston Society of Civil Engineers to consider the matter of a division of the additional office room space; as this committee, President Sullivan appointed Edward C. Sherman, chairman; Samuel E. Killam, Albert S. Glover, D. A. Heffernan, and Willard Kent.

It was voted that the expense of the chairman of the Committee on Service Pipe Investigation recently incurred in traveling be reimbursed him by the Association.

The Secretary read a letter from Mr. F. H. Newell, chairman of a special committee of the American Society of Civil Engineers appointed to consider the expediency of establishing "A National Water Law," and asking the consideration of our Association to the matter and the appointment by us of a similar committee to coöperate with said committee of the American Society of Civil Engineers. After due consideration of the matter, it was voted: That a committee of three members be appointed from our Association on this matter; and the President named as said committee Messrs. Caleb M. Saville, Alfred D. Flinn, and Carleton E. Davis.

Adjourned.

Willard Kent, *Secretary.*

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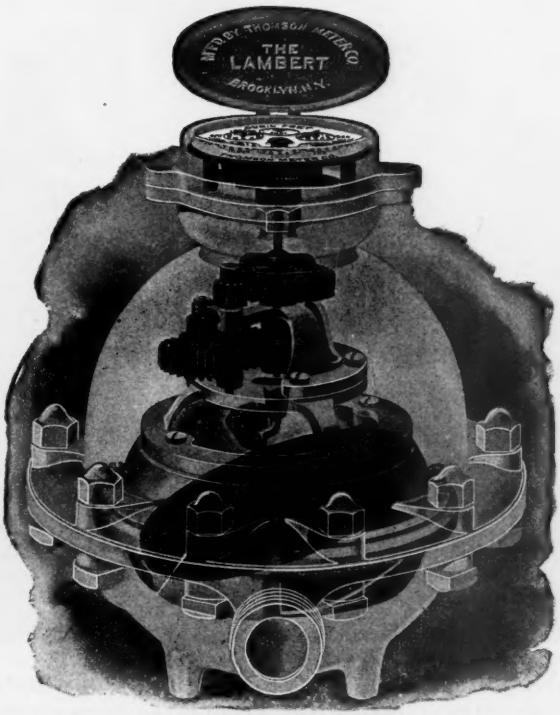

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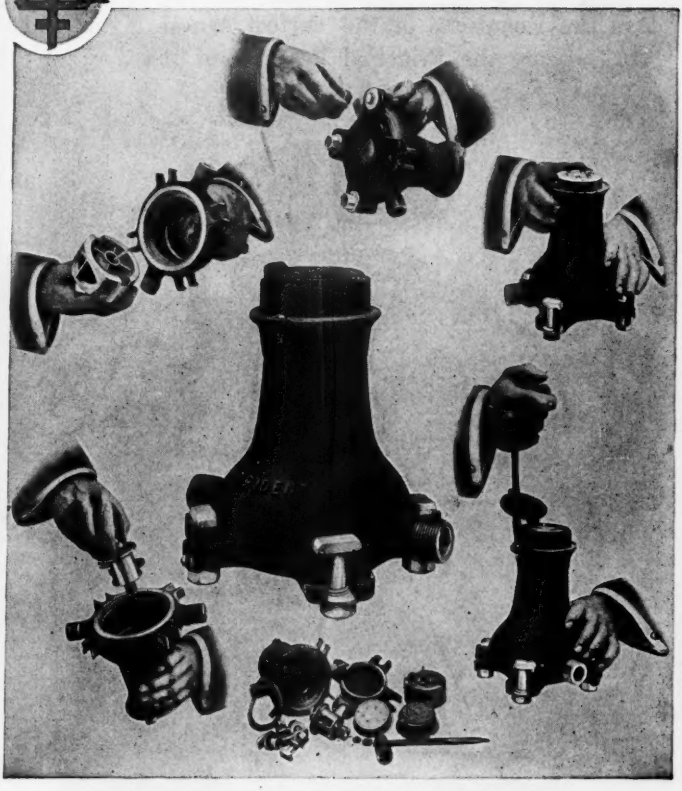

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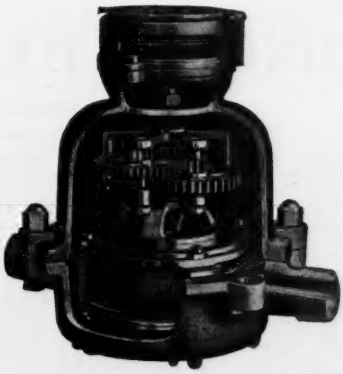

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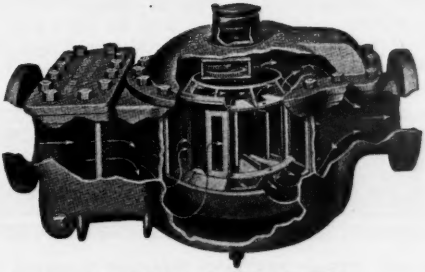

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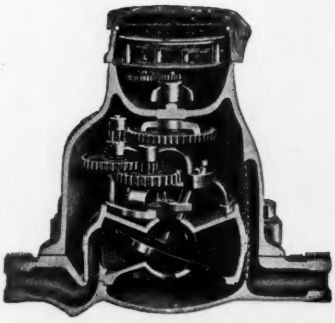
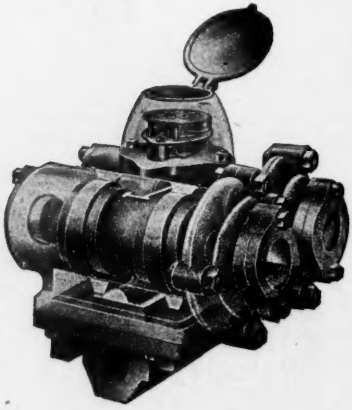
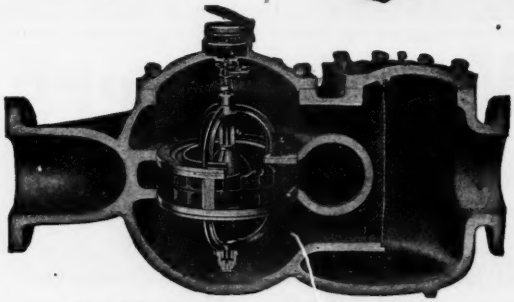




The Worthington Disc Meter combines minimum weight with reliability on constant service and accuracy of registration.



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Full descriptions of the different types of Worthington Meters, with tables of sizes and capacities, are given in Bulletin W184–54.

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W159.8

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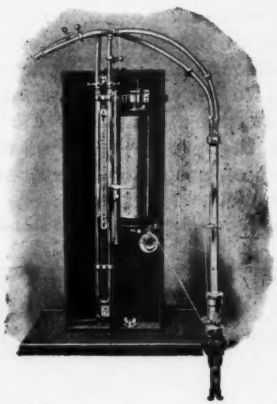

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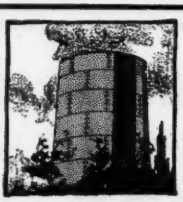

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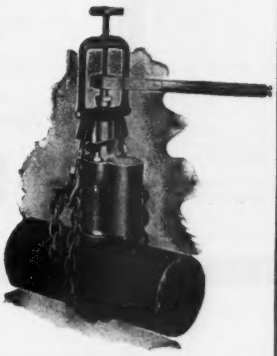

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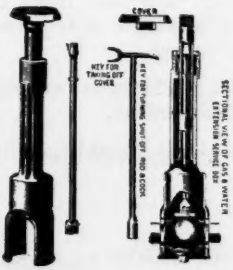

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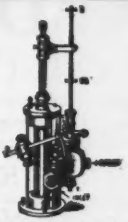

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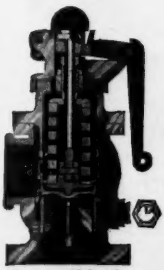

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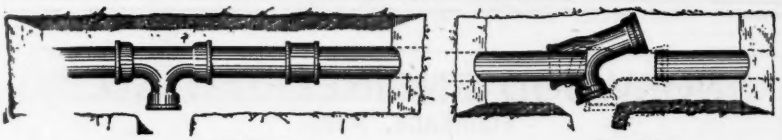

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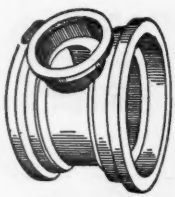

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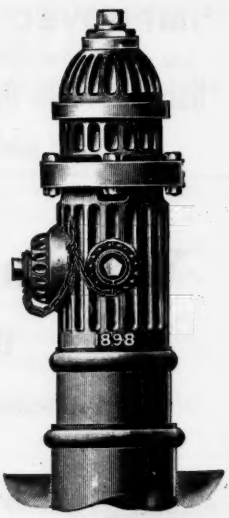

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A half century of use has established their reputation as being the most economical, durable and simple hydrant.

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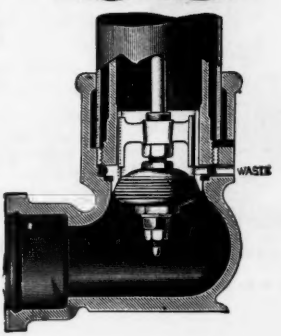

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DOUBLE DISK
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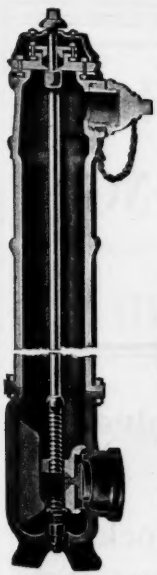

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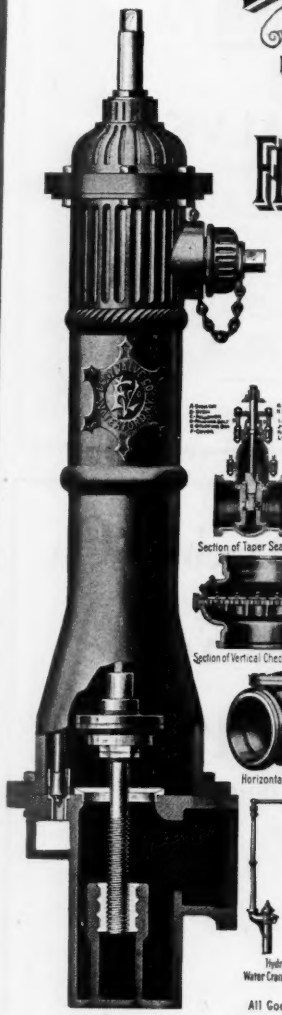
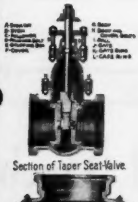
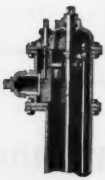
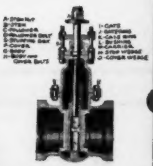




Section of Taper Seat-Valve.



Hydrant with Independent Nozzle Cut-off.



Section of Parallel Seat-Valve.

Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

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Hydrant with Water Crane Attachment.

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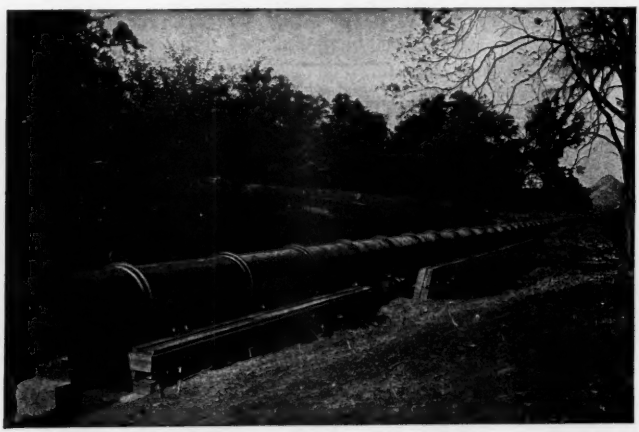

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Over 100 Water Departments

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For calking pipe joints under the most difficult conditions.

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NO FIRE — NO DANGER — NO TROUBLE.

Highest quality Lead Lined Iron Pipe and Fittings

***Also* Pure Block-Tin Lined Iron Pipe and Fittings**

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Hydraulically and Electrically operated valves and sluice gates

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YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
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